Science and Experiment as Applied to Canning

TX
603
.D38

THE LIBRARY OF CONGRESS
1800

Class TX602
Book .D38
Copyright N°

COPYRIGHT DEPOSIT.

Regards of
A. R. Keming
Nov xii/02

A MODERN MANUFACTORY OF CANNING MACHINERY.

Science and Experiment as Applied to Canning

EDITED BY

O. L. DEMING

OF THE "CANNER AND DRIED FRUIT PACKER"

14/9572

PUBLISHED BY

SPRAGUE CANNING MACHINERY CO.,

CHICAGO

TX603
.D38

THE LIBRARY OF
CONGRESS.
ONE COPY RECEIVED
NOV. 26 1902
COPYRIGHT ENTRY
Dec. 1-1902
CLASS a XXc. No.
47293
COPY B.

COPYRIGHTED, 1902,
BY
O. L. DEMING,
CHICAGO.

INDEX

INTRODUCTION.

The editor of the CANNER AND DRIED FRUIT PACKER has frequently received requests for copies of issues containing the various valuable scientific articles which have appeared from time to time in its columns, and as it is no longer possible to furnish a complete set of such articles in that form it has been suggested that the more important articles be combined, and published in book form. Acting on this suggestion, which I consider timely and even vital to the interests of the canning trade, I have gathered together such articles as are essential to a work of this character and offer them with the hope that they will materially assist in placing the canning business on a more accurate and therefore more scientific basis.

The principal papers are from the pens of Prof. S. C. Prescott, of the Massachusetts School of Technology, and W. Lyman Underwood, of Boston, Mass., who are the pioneers in bacterial research as relating to canned goods and to whom the canners of the United States owe a debt of gratitude if nothing more. A sort of strange coincidence is connected with the first investigation into the causes which developed sour corn and which had proved a serious menace to the packers of that article. Mr. W. Lyman Underwood is a member of the firm of Wm. Underwood & Co., of Boston, which firm, with other articles of food, is a heavy packer of lobsters, which from an early date gave much trouble and anxiety to the packer by frequently turning black in the can. After various reasonings and experiments, all of which resulted unsatisfactorily, Mr. Underwood decided to make a thorough scientific study of the question, and, under the advice and leadership of Professor S. C. Prescott, entered into an exhaustive research and investigation of the bacteria affecting lobster. As Mr. Underwood pursued his studies he became enthused with the work, and, together with Professor Prescott, continued his investigations in other lines of canned goods, chiefly corn, and later on peas. Eastern canners first became aware of the scientific work being done by these gentlemen and naturally became very much interested and even anxious to learn the results of these pioneer investigations into the almost unknown ground of bacteria as relating to canned goods. It is a remarkable fact that up to the time of these investigations by Professors Prescott and Underwood the "art" of canning was a dense and tangled underbrush

of theories, hedged about by mysterious nods and winks; factories were jealously guarded as if they contained some enchanted secret and it was almost as difficult to secure admission as it was to break into the vaults of a bank. All this arose from carefully guarded ignorance on the part of the canner and his desire to protect what little information he possessed regarding the process of canning. The canner himself really knew so little about the science of canning that he was compelled through caution to throw the glamour of secrecy over nearly every movement in order to protect himself and his lack of skillful knowledge. Canning seemed more like an intrigue than a legitimate commercial business; the act of self-interest which brought Mr. Underwood and Professor Prescott together was really the first attempt ever made to place the canning business on a safe and solid basis of action.

The growth of the industry has been very rapid, and the development of the machinery for the different operations necessary in canning factories has kept pace with its enlargement. The opening article, containing an outline of the early history of the corn packing industry, will be of interest to all, with its illustrations of the crude appliances first used. Devices first starting with home made and experimental apparatus were developed in a scattered way throughout the pioneer factories in the industry. Necessity has never more truly proved its title, "the mother of invention" than in the canning line. From the crude experimental machines there have been developed for the purposes of the canner, machinery and appliances, perfect in all their details, and automatic in their operations, many of which have a capacity for handling products in different departments at a rate of upwards of 40,000 cans in ten hours; automatic canning lines have been developed in which each machine has been designed with particular view to its automatic operation and relation to other machines performing the different parts of the work, and instead of canning machinery being made in a small way by scattering individuals and inventors throughout the country, there are now manufacturing concerns of considerable size devoting their attention exclusively to the manufacture of canning machinery and appliances, and the further perfecting of automatic systems for handling every article put into a can.

Papers by the well-known entomologists Professor E. Dwight Sanderson, of Newark, Del., and Professor W. G. Johnson, of Maryland, as well as other authorities, are also incorporated in the compilation.

THE EDITOR.

CHAPTER I.

HISTORICAL.

The most reliable historical article on the canning of corn ever published is from the pen of Mr. F. O. Conant, of Portland, Me. The article was written by request and the author made most careful and thorough search of many historical documents for the facts presented. The article was read at the annual canners' meeting held at Cincinnati in February, 1897. Mr. Conant addressed the convention as follows:

Gentlemen: When our president asked me to prepare a paper for this meeting I could think of no subject connected with the packing industry with which I was familiar enough to prepare a paper which would be likely to have any interest to a body composed principally of Western packers, except a sort of sketch of the early days of the trade in Maine. It may seem like presumption for one whose connection with trade has been so short to attempt this subject, but the sources of information are open to all, and many of the pioneers are still with us in Maine, able and willing to give information to those who seek it, and so I decided to make the attempt though very conscious of my own deficiencies and lack of ability.

The evolution of the canning business is a very interesting phase of the life of the down-East wage earner, and many who were once wage earners are now capitalists, owing the bulk of their fortunes to the canning business. It is well-known that the process of preserving food in bottles by a method quite similar to our present process of canning is not a recent invention. The first record of it appears in a paper submitted by the English Society of Arts in 1807, under the title "A Method of Preserving Fruits Without Sugar for House or Sea Stores," by a Mr. Saddington. The method then described was to fill bottles with fruit, loosely cork, place them in a vessel containing cold water, which should reach to the necks of the bottles, and gradually raise the heat to a temperature of about 75 degrees, keeping it there for half an hour. The manipulator was cautioned not to heat higher or longer or the bottles would be liable to burst. Then the bottles were to be filled with boiling water, corked immediately and laid upon their sides in order that the hot water might swell the corks. The operation was completed by cementing the corks. Credit has generally been given, however, to M. Appert, a Frenchman, who was the first to make prac-

tical use of the process on a large scale. His work on the subject was published in 1810, he having received a prize of 12,000 francs offered by the French government in 1809. There was also an English patent granted in 1810 to Peter Durrand for preserving animal food, vegetable food and other perishable articles.

The method of preserving food by canning in its present form appears to date back to the patent of Pierre Antoine Angilbert in 1823, though it is said to have been in practical use three years earlier. This method did not vary essentially from present practice. The food, together with some water was placed in a tin can, a lid carrying a minute aperture fastened on and heat applied. When the liquid in the can boiled briskly, and all the air had been expelled, the hole was closed by a drop of solder.

Maine has been generally acknowledged as the early home of corn packing in this country, and its claim is a just one. Some small quantities of oysters were packed in Baltimore, and lobsters, fish and perhaps fruits were packed elsewhere previous to the canning of corn in Maine, Edward Wright having started to pack oysters in Baltimore between 1838 and 1840. The late Thomas Kensett, who was considered one of the fathers of the industry, did not establish his business in Baltimore till 1850. At about the same time as Wright, Isaac Winslow began his experiments in canning corn at or near Portland. Isaac Winslow was a native of Maine and at some time previous to 1840 was engaged in the whaling business with a brother who lived in France. During some of his visits to France he learned of the process of preserving foods, probably through the purchase of supplies to fit out his whaling ships, and conceived the idea of preserving green vegetables by hermetically sealing them in cans. Scurvy, a disease brought on by sameness of food, was then a dreaded disease among sailors, so a person connected with the sea would be quick to see the advantage of such a process, which would enable vessels to carry a varied diet safely preserved against the varying temperature a long voyage would necessitate. Winslow too had a fondness for inventions and inventors and at this time had nearly dissipated a large fortune in advances to inventors of numerous processes, machines, and articles, all of which were warranted by the inventor to make the owner and controller of the invention immensely wealthy within a short time. Some of us machinery men have had similar sad experience, so when you packers object to the profits of certain machines, please remember the good money which has gone into unfruitful experiments and the long series of trials necessary before the first inventive idea results in the perfect machine.

Isaac Winslow, then, in 1839 began his experiments on corn, which for a long time proved unsuccessful. He, about 1842, arranged with Caleb Jones, a brother-in-law, (and father of John Winslow Jones, at one time the king of the canned goods trade in Maine), to plant a piece of green corn for experimental purposes. This is the first appearance of the name of Jones in connection with the industry. Winslow's first trial was by cooking the whole ear of corn, but the article obtained was so bulky and he thought the cob absorbed the sweetness, that this way was abandoned

also, and he next tried to remove the kernels whole by pulling or pushing them off the ear with a kind of fork. But this was soon abandoned also, and the kernels cut from the cob. The first experiments in cooking were made in a common household boiler and in a very small way. When boiling he was accustomed to treat little lots to varying degrees of heat and various times, then mark each lot and pile it away and await results. The results were mostly one way, that is, the corn spoiled after a little while, but enough kept to give Mr. Winslow confidence in his ultimate success, and this confidence was increased from the fact that the portion of corn which kept proved to be of very superior quality and was much complimented by his friends, among whom he distributed it. In 1843 he prepared for more experiments and caused to be built a small steam boiler made of copper that would hold about two barrels of water and would carry 10 or 12 lbs. of steam, and attached to this wooden tanks lined with zinc and made steam tight. In these tanks he processed his corn, subjecting it to the direct action of steam without water. For some reason nearly the whole lot experimented upon in that year spoiled, and the steam apparatus was abandoned. The next season, or in 1844, he went back to the process of boiling in open boilers. About 1842 Nathan Winslow, a brother of Isaac, joined with him in the experiments. Nathan Winslow was a dealer in stoves and tinware, and his shop was next to my grandfather's place of business on Fore street, Portland. The cans used in these experiments were made in his shop and I have heard my father relate that about this time the rumor that the Winslows were engaged in some secret experiment being noised about, he with other boys climbed the roof of his father's store and so gained access to a scuttle window in the roof of the Winslow store where he could see Winslow and his workmen busily engaged in making tin cans of a strange form. They were of strange form, as the example I now exhibit will show. This is supposed to contain corn, though that is not certain. At any rate it is one of the cans packed by Nathan Winslow about 1852.

Isaac Winslow continued his experiments with varying success until about 1853, when, thinking the process had at last reached a stage warranting the step, he applied for a patent. His claim for the protection of a patent was not allowed at this time, and it was not till 1862 that the patent was finally issued, and then it was to John Winslow Jones, assignee of all interests to Isaac Winslow. An extended abstract from the original patent (or patents, for there were four of them) of Winslow may be of interest. He says, "After a great variety of experiments I have overcome the difficulties of preserving Indian corn in the green state without drying the same, thus retaining the milk and other juices, and the full flavor of fresh, green corn, until the latter is desired for use. Instead of a hard, insipid or otherwise unpalatable article, I have finally succeeded in producing an entirely satisfactory article of manufacture, in which my invention consists. I have employed several methods of treatment—my first success was obtained by the following process: The kernels being removed from the cob were immediately packed in cans and the latter hermetically sealed, so as

CAN USED BY CORN PACKERS ABOUT 1852

to pervent the escape of the natural aroma of the corn, or the evaporation of the milk and other juices of the same; then I submitted the sealed cans and their contents to boiling or steam heat about four hours. In this way the milk and other juices of the corn are coagulated as far as may be, boiling thus preventing the putrefaction of these most easily destructible constituents. At the same time the milk is not washed away or diluted, as would be, more or less, the case if the kernels were mixed with water and then boiled. By this method of cooking green corn the ends of the cans are bulged out as though putrefaction and escape of the resultant gases had commenced within the cans; consequently strong cans are required, and dealers are likely to be prejudiced against corn thus put up. I recommend the following method: Select a superior quality of green corn in the green state, and remove the kernels from the cob by means of a curved and gauged knife or other suitable means. Then pack these kernels in cans and hermetically seal the latter so as to prevent evaporation, under heat, or the escape of the aroma of the corn. Now expose these cans of corn to steam or boiling heat for about one hour and a half; then puncture the cans, and immediately seal the same, while hot; and continue the heat for about two hours and a half longer. Afterwards the cans may be slowly cooled in a room at a temperature of 70 degrees to 100 degrees Fahrenheit." For many years the fact of the preservation of foods treated by these processes was ascribed solely to the fact that all air is expelled from the can during the process of canning, it being supposed that air was absolutely essential to the growth of putrefaction germs. But this is not so, for it is well known to scientists that some of the common bacteria which cause putrefaction can live without atmospheric air or that air is even fatal to them. It follows that the mere presence or absence of air in the can is a matter of no importance in itself. Tyndall demonstrated that air plays no important part in putrefaction save as a carrier of bacteria. Winslow was well aware that it was not the air inside the can which spoiled the corn, for he says: "The air contained within the cans at the time of sealing and also the vapor from the corn become more or less expanded, so as to press out the heads of the can, thus giving the appearance of spoiled corn. When the cans are not punctured their ends will remain outward after cooling, and yet the corn is perfectly preserved."

Nathan Winslow engaged in packing as a business in 1852, and in 1853 took his nephew, John Winslow Jones, into company with him. Their business gradually increased and the firm continued in the trade till 1861 or 1862, after which time Jones continued the business alone, and for many years was the largest packer in the state, and in addition to the corn packed by himself, bought largely of others, selling all under the well known yellow label bearing the title "Winslow's Patent Hermetically Sealed Green Corn." The first sale of corn which has been found is from Nathan Winslow to Samuel S. Pierce of Boston, the invoice being dated Feb. 19, 1848, and was for one dozen canisters preserved corn at $4.00.

In 1867 Jones brought suit against R. K. Sewall, administrator of the estate of Henry Clark of Wiscassett, Maine, for packing corn without a

license. This suit was bitterly fought in the U. S. Circuit Court before Judge Clifford and a decision was not given till May, 1873, when an accounting was ordered and an injunction given. In course of this suit nearly every person who had ever been connected with the canning business in Maine gave testimony on one side or the other. This decision favorable to the Winslow patents caused great commotion among the packers all over the country, and some hastened to take licenses from Jones, then owner of the patents. They agreed to pay a royalty of 25 cents per dozen on all corn packed for the remainder of the life of the patent or till 1878. An appeal was, however, taken to the Supreme Court of the United States and in October, 1875, Judge Clifford's decision was reversed and the Winslow patents declared invalid.

In June, 1876, Jones having secured a patent on an improved knife for cutting the corn from the cob and also by surrendering his former patents and amending specifications having secured a new patent on the process, brought suit against Louis McMurray & Co., of Baltimore. This suit, like the earlier one, drew into it as witnesses or interested parties nearly all who had ever had anything to do with canning all over the country. This suit was finally compromised.

Mr. Jones, in 1880, organized the John Winslow Packing Co., Ltd., in which a large amount of English capital was interested, but for some reason the company was unsuccessful, and was succeeded in 1882 by the Winslow Packing Co., organized by Col. C. P. Mattocks of Portland, which did a very large business for several years packing corn and lobsters principally, and in 1887 sold 203,000 cases of corn which was sold at $1.10 to $1.25 per dozen. Their brands were the Globe (170,000) and Snow Flake (63,000).

Mr. Jones afterwards removed to Maryland and is still selling corn packed at Portland, but the letters indicating the state upon his labels are Md. instead of Me.

When the Winslow Packing Co. went out of business, a large number of firms for whom it had acted as selling agents began packing on their own account and under their own brands, and new companies were organized to operate its abandoned factories. Among these were A. & P. B. Young of Hiram, the Minot Packing Co., of West Minot, the Norway Packing Co. and others

In 1839 Upman S. Treat of Eastport, Maine, engaged in packing salmon at St. Johns, N. B., and in 1841 removed to Eastport, where the firm of Treat, Noble & Co. was formed, composed of Treat, Isaac Noble, Charles Mitchell, Tristram Halliday, and engaged in packing lobsters and salmon. Treat withdrew from the firm in 1843 and the business was carried on by Noble and Mitchell. Treat afterward entered the business again. They put up some corn for experiment at an early period and continued in business till 1856. The corn canned by them was shipped from Boston by steamer. Treat claimed that he sold the first canned salmon that was ever sold in this country in 1841, and that he put canned lobsters on the market in 1842 or 1843. He claimed that at that time he visited all

the large cities, Boston, New York, Philadelphia, Baltimore and Washington, without finding canned salmon or lobster.

Noble & Mitchell sold out to William Underwood & Co. about 1845, who did not pack corn largely themselves, but bought from others. The firm of W. K. Lewis & Bros. seems to have been the next firm to engage in the trade. They put up some goods in Boston in 1843, but in 1845 started a factory in Portland on Custom House Wharf, preserving mostly meats, fish and perhaps some corn.

In 1849 Henry Evans, afterward of the firm of Evans, Reeves & Co. of New York and Baltimore, had a packing shop on Custom House Wharf near Lewis' shop. He learned the trade of U. S. Treat at Eastport. He only remained in Portland about a year.

In the same year Aaron King opened a cannery in Portland, packing lobsters, peas, meats, etc., on Burnham's Wharf. He soon took into partnership with him a man named Hartshorn. King was afterward processor for Henry Clark, the man against whom Jones brought suit. In 1853 King put up about 20,000 cans and in 1854 about 40,000 cans.

The next firm to enter the business was Rumery & Burnham, composed of Samuel Rumery, who died some twenty-three years ago, and George Burnham, Jr., now the senior member of the Burnham & Morrill Co. Samuel Rumery had learned the trade at Eastport with Treat, Noble & Co. about 1844 or 1845, he was next a member of the firm of Lewis & Co., at Portland, in 1846 and 1847, then was with Nathan Winslow & Co. in 1849. In 1850 he was with Wells, Miller & Provost in New York City, but soon returned to Portland and in 1852 went into business with George Burnham, who had learned the trade with Lewis & Co. Their principal business was at first the packing of meats, fish, clams, poultry, and lobsters, but corn was added to the list about 1853 or 1854. In 1855, they bought out Kemp, Day & Co., who had started a packing house near the entrance to the canal. Kemp, Day & Co.'s shop was built over a large depression in the ground, but not a regular cellar, and after Rumery & Burnham moved into it they found this hollow under the building full of cans of spoilt corn, which had been hidden there by the workmen without the knowledge of Kemp, Day & Co. It was estimated that there were 10,000 cans in the lot, and as corn then sold at $3.50 per dozen, this would account for quite a portion of the loss they admitted by this venture. Rumery & Burnham continued in business together till 1867, when the partnership was dissolved and the firm of Burnham & Morrill formed, which continued till within a few years, when the business was incorporated as the Burnham & Morrill Co.

The firm of Davis, Baxter & Co. was the next firm to enter the business. They had been engaged in importing cutlery and fancy goods for some years, but in 1861 began to pack lobsters, and 1862, in connection with Rumery & Burnham, established the Portland Packing Co. The company was owned jointly for about four years, when Davis, Baxter & Co. bought the interests of Rumery & Burnham. When the firm of Rumery & Burnham dissolved in 1867 or 1868, Rumery joined the Portland Packing Co.,

which was then composed of William G. Davis, James P. Baxter, now and for three years past Mayor of Portland, and Samuel Rumery, who continued in the firm till his death in 1874. The firm is still in existence, doing a large business, and now composed of sons of the original proprietors.

Plummer & Marr were one of the early firms in the business. They had a factory in Portland and another at South Paris, but sold out to the Portland Packing Co. about 1866.

A. H. Burnham, of Bridgton, who is well known to many of you, having attended these conventions for many years, began business with Nathan Winslow in 1852. He was then with Rumery & Burnham for a while, but soon went back with Winslow and continued with him and his successor, Jones, as long as they remained in business. For a number of years he was general superintendent of the Winslow Packing Co.'s factories in the western part of the state, had a better practical knowledge of the business than he. He now runs his own Waterford factory, and is also interested in the two factories of the Bridgton Canning Co.

J. P. Jordan first entered the business as broker in 1879, but in 1882 began packing on his own account at New Gloucester, and in 1884 added other factories, organizing "The United Packers," of which he is treasurer, in 1889. His office in Portland is in the same building occupied back in the "forties" by Nathan Winslow, Maine's first corn packer.

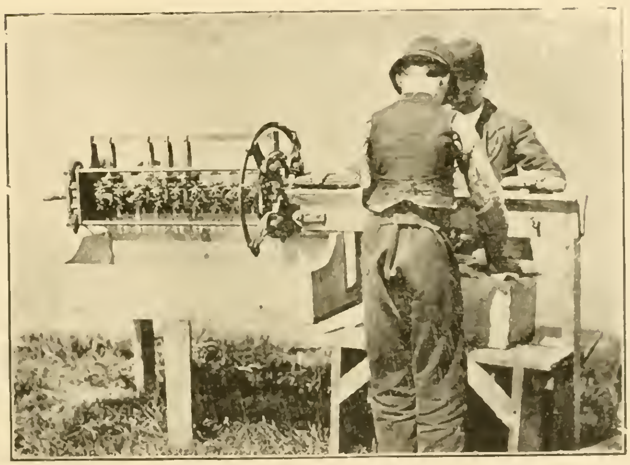
H. F. Webb & Co. began business in 1881 at Rumford, but of late years have packed the largest part of their output at Leeds and Gray. His "Cream" brand has a high reputation with the trade. Mr. Horace F. Webb, of this firm, is a son of Mr. James B. Webb, who first entered the packing business at Gorham, Me., about 1865, as a member of the old Gorham Packing Co.

In 1888, a number of new firms entered the field, among them H. C. Baxter & Bro., Fernald & Keene Bros., now Fernald, Keene & True Co., the Winterport Packing Co.

There are many other firms as deserving of record as those mentioned, but time forbids. Among those still in active business are Fred T. Flint, with factories at Cornish and Kezar Falls; T. L. Eastman, Fryeburg; Merrill Bros., with factories at Lisbon and Yarmouth; E. S. Goding, at Livermore Falls; Bonney, Wheeler & Dingley Co., Farmington Falls; N. C. Cumings & Bro., Portland; Henry S. Payson Co., Portland; Henry L. Forhan, Raymond; C. T. Moses, Corinna; Norton & Wingate, East Baldwin; Twitchell, Champlin & Co., and Thompson & Hall, of Portland; J. & E. H. Wyman, Readfield, and D. W. Hoegg & Co.

Like most other manufacturing industries carried on by enterprising and ingenious men, the method and process of packing sweet corn has undergone a complete change since its commencement, though the principle remains the same. This is mostly through the use of improved machinery. At first the corn was cut from the cob by a common case knife; the knife then took a curved form, shaped to the ear of corn, and a gauge added before 1853. In these days the cutters were the most numerous body

CORN "CUTTER" OF 1850



THE FIRST SPRAGUE CORN CUTTER (INVENTION OF WELCOME SPRAGUE

of workmen about the factory. For instance, in the year 1869, 800 hands were employed at the Bridgton factory, of whom 375 were cutters and only about 100 huskers. This continued until about 1875, when machines run by hand came out, invented by Volney Barker. The power machines came into use about 1886, Sprague's first and then the Barker machines.

Jones was the first packer to use ice for the purpose of keeping the corn cool from the time of cutting till filled into cans. This he did about 1863.

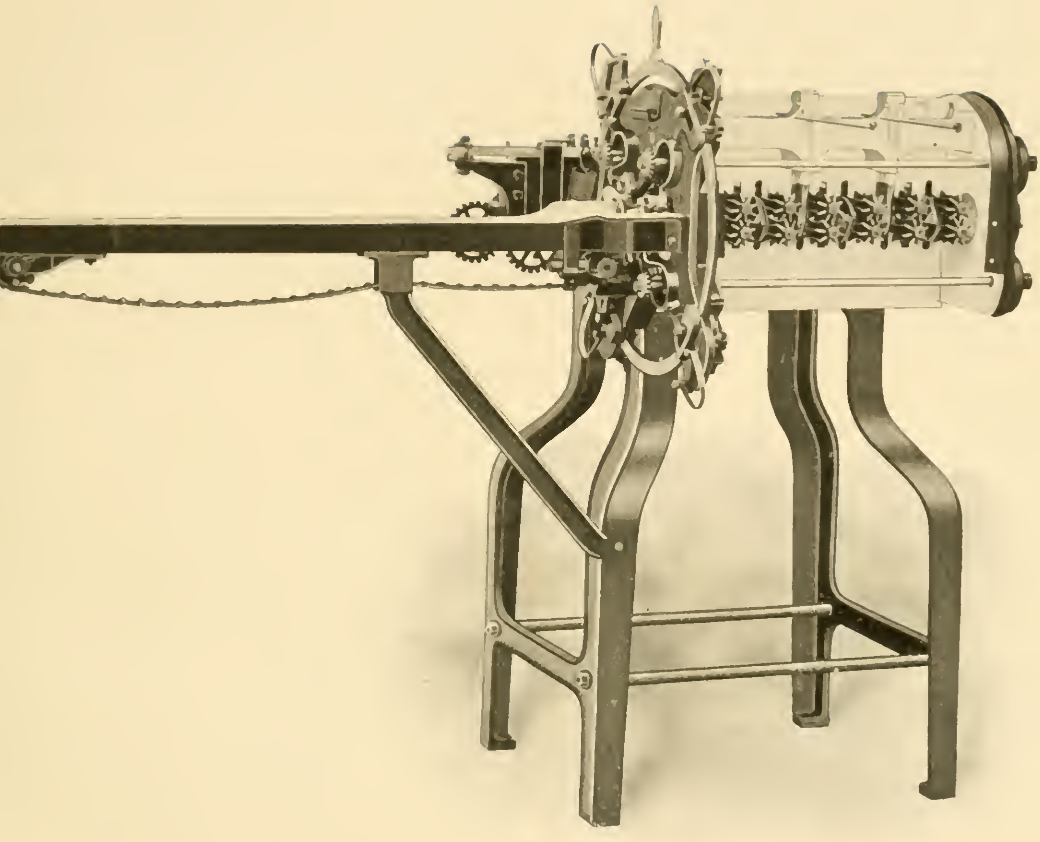
The old hand press for filling cans came into use at an early period in the history of the industry and was not superseded, in Maine, at least, by machine work until quite recently. In 1878 Barker took out his first patents on a power filler, but not until 1885 was his machine made practical, and then it was totally unlike the first one. The Stickney filler came out in 1883 and had a large sale. These machines were in general use when the hot process which had been used in the south for a number of years was introduced in 1890. Wiping machines were introduced by Barker about 1883, but the brush machines have displaced his machine since 1888.

In the "sealing" department Maine is perhaps behind other states, for most factories still "cap" by hand. Some power capping machines have, however, been introduced, and we may expect their use to become general very quickly. Mr. E. M. Lang of Portland has introduced several valuable improvements in soldering irons, one of which was introduction of a tool made of steel instead of copper. Mr. Lang's patent was granted in 1876, but he never enforced his claims to royalty, and the patent expired in 1893. Mr. Lang was also the inventor and patentee of segment solder, which he introduced in 1876.

The processing of the corn also shows the march of improvement. At first many packers outside of the Winslows cooked the corn before filling it into the cans. The Winslows filled the cans with uncooked corn, then, after sealing, the cans were cooked in an open bath for about two hours, vented, resealed, and boiled for two hours and a half or three hours longer, Some packers vented twice with a cooking of an hour and a half between, and a total time of about five and a half hours. The time of the "bathing" was gradually reduced, in one case by the addition of salt or chemicals to the water, which then required a higher temperature to boil it, and so permitting a shorter cooking. About 1879 the time was still farther shortened by the introduction of steam retorts, which reduced the time of the last cooking to one hour. Next and last came in the "cookers" (Conant's, of course, preferred), which did away with the first bath, and also with a large number of hands previously needed in the bath room.

It is probably safe to say that Maine has packed more corn than any other state, and for the last five years Maine's pack has been second only to that of New York, Maine having produced 3,101,883 cases and New York 4,378,000. Illinois comes third with a pack of 2,352,000 cases.

This paper has been confined closely to the canning industry as related to corn, but Maine firms are heavy packers of lobsters, sardines, blueberries, clams, etc., but I am not familiar enough with the subject to attempt it in this paper.



THE SPRAGUE CORN CUTTER OF 1902 (LATEST IMPROVED MODEL M)

In conclusion, let me say that I have endeavored to outline the evolution of the canning industry in Maine. Speaking of the discovery of the art in general, it was a revolution, for by its realizations and its future possibilities this discovery was of the greatest economic value in preventing the waste of property, giving of employment to millions of capital and thousands of laborers. It gives employment to the miner in the mountains of Wales and in the coal and iron fields of our own country, to the lumberman and nail manufacturer, to the farmer, the laborer, the machinist, the engraver, the printer, the artist, and gives thousands of car loads of freight to the railroads. It would be difficult to find an industry in which greater variety of talent and skill is employed or one in which the investor finds so large and profitable a field. Its products are truly cosmopolitan, for they go north, south, east and west, and are available in every climate. Maine is a small state, compared with its sisters in the west and south, and the area in which sweet corn can be grown and packed is limited, but as an offset to our long, cold winters, our rocks and hills, we can boast that Maine produces the best sweet corn in the world.

(Mr. Conant at the next annual meeting held at Buffalo, February, 1898, referred to his paper of the previous year. His remarks were somewhat supplementary to this paper, as they embodied the discoveries of a recent research which he had made among the papers belonging to the Historical Society of Maine. In the paper of the preceding year it was brought out that the first instances in canning known were of the date 1807 or 1810. In the second research he had found a paper of the date of January 9, 1840, which contained an item stating that twelve tin packages containing French peas were found in the wreck of the Royal George, which occurred August 29, 1792, or nearly twenty years previous to the earliest known history regarding the packing of canned goods. Mr. Conant referred to the fact that it was about the time of the date of the publication of this paper in 1840 that Nathan Winslow first commenced experimenting in the processes of canning vegetables, and thought the inference very strong that Nathan Winslow received his first inspirations from the paragraph referred to. This is certainly a very valuable acquisition to the canning history of America.)

CHAPTER II.

The letter which follows answers as an introduction to the papers and discussion on the souring of corn. This letter was written in November, 1897, by W. Lyman Underwood, and the comment which follows appeared in the CANNER AND DRIED FRUIT PACKER of November 4, 1897:

DETERIORATION IN CANNED GOODS.

Editor Canner and Dried Fruit Packer:

As you doubtless know much interest has been manifest in some quarters regarding the deterioration occurring in some kinds of canned goods, of which lobsters and corn are two notable examples. In Canada the question has become so serious, that the Canadian government recently employed a specialist to investigate the lobster packing business, with the view to finding out the causes of deterioration of canned lobster (i .e., black lobster), and if possible to find methods of prevention. This, however, is not the first work which has been done on this subject. On October 8, 1896, a paper on "micro-organisms and sterilizing processes in the canning industries" was read before the Society of Arts in Boston by Mr. C. S. Prescott, of the Massachusetts Institute of Technology, and myself, and afterwards published in the *Technology Quarterly*. You may also be interested to learn that for nearly a year we have been investigating the bacteria conceived in the spoiling of corn, "sour corn," and hope to publish an article on this subject in a short time.

W. LYMAN UNDERWOOD.

The paper referred to in the above letter will prove interesting to the packers of canned goods. We regret limited space will not permit the publication in this issue. The authors have carefully reviewed the canned goods industry in the United States, and have devoted considerable study to processes in canning. Under the head of Examination of "Swelled" Cans and Descriptions of the Bacteria Found, they say: Our investigations began with a careful examination of a large number of cans of spoiled clams and lobsters. The contents of such cans were found to be badly decomposed, in some cases almost entirely liquefied, much darkened in color, and of a very disagreeable odor. Bacterial examination showed that in every case where spoiling had occurred, living bacteria were present in great numbers. In sound cans, on the other hand, no living bacteria could be detected, and the contents proved to be sterile. As would be supposed in the present state of bacteriology, there is no reason to doubt that swelling

and decomposition are invariably the result of bacterial action. In some cases a can contained a culture apparently pure, while other cans might contain a mixture of sweet species. The ordinary bacteriological methods, with some modifications, served for the separation of these organisms into distinct species, and made possible their cultivation in pure cultures in artificial media. Of the nine species of bacteria obtained, two are micrococci, while the other seven are classed among the bacilli. All of them are noticeably rapid in their development in an incubator at blood heat (98 deg. F., $37\frac{1}{2}$ C.) both in liquid and on solid media, while they grow slowly at a temperature of 70 deg. F. (20 deg. C.). They may be readily stained by the usual staining reagents. In some several of the forms endospore formation has been observed, and these forms are likewise noticeable for the rapidity with which sporulation occurs. Detailed descriptions are given which show some of the characteristics of the above species.

FIRST PAPERS ON SOUR CORN.

At the annual meeting of the Atlantic States Packers' Association held at Buffalo in February, 1898, President Palmer announced that the committee had secured the presence of Prof. Prescott and also W. Lyman Underwood, who would discuss in detail the results of their investigations. These gentlemen addressed the convention Wednesday, February 9th, and were introduced by the chair, as follows:

Several years ago Mr. Underwood, of the firm of Underwood & Co., of Boston, began the study of bacteriology at the Massachusetts School of Technology, and has been following it ever since, with the special object of solving some of the problems which have arisen in the canning business. Mr. William Underwood is a member of the firm of Underwood & Co., and he and his family have been in the canning business for three generations. His grandfather was one of the pioneers. As you know they are packers of high grade fish, meats, soups, etc., and have a reputation throughout the country. Mr. Prescott is a professor at the institute, and Mr. Underwood and Mr. Prescott together have been studying this subject, and they wish it to be understood and given out that their labors have not been separated in any way. What they have found out, and what they have done has been the result of their joint work. I think these papers are going to be of a great deal of use to the canned goods packer. It is a subject that is very important indeed, and "sour corn" has caused the packers of corn to lose thousands of dollars in the last few years. The paper which is to be read by Professor Prescott is going to be published in the *Technology Quarterly,* which will appear about March 1, and therefore he wishes it given out that it will not be printed in full by the trade papers until it so appears, as his work was done in the interest of the institution, and the *Quarterly* publishes this kind of work, and they feel they are under obliga-

tions to have it appear in the *Quarterly* first. Mr. Underwood will speak to you first.

Mr. Underwood spoke as follows:

It gives both Mr. Prescott and myself great pleasure to address you this morning, and it is our hope that some benefit may come from the work which we have undertaken. We shall not attempt to lay down any hard and fast rules for the prevention of some of these troubles, which occasionally make themselves manifest in the canning industry. It is probable that, at times, we have all of us had more or less spoiling of some of our products.

It may interest you to hear how I happened to take up this study of germs or bacteria, in connection with my business. Some three or four years ago I became aware of an entirely new form of spoiling, in some of the goods which we packed. This was similar in a way to that which sometimes takes place in canned lobster, known to the trade as "Black Lobster." The contents of the can were turned to a black, foul smelling liquid, without swelling or giving any outward indications of anything being wrong within. Luckily this condition of things was discovered at the factory before any shipments were made; for by shaking the cans their liquid nature would be detected. At the same time we were having a good many swells in the same goods.

I was a great deal worried and naturally very anxious to find the cause of this new state of things. I had an idea, as, of course, most of you have, that to kill all germs was one of the fundamental principles of canning; though just what these germs were, was very dim in my mind, neither did I, at the time, in any way, connect them with our trouble. It seemed to me more a matter of chemistry. But after a great deal of thought I finally went to the Massachusetts Institute of Technology, and consulted with Prof. W. F. Sedgwick and explained to him the nature of the difficulty. He told me that, to his knowledge, no scientific investigations had been made of the canning industry, and it seemed to him that bacteria or germs were the cause of the trouble, and to become acquainted with these things would require the study of Bacteriology. Accordingly, I became associated with Mr. S. C. Prescott of the Biological Department of the Institute. He taught me the principles of Bacteriology which apply to our business; while, at the same time, he learned from me that practical part of canning which applies to his study.

It was some time before we began actual work on spoiled goods, our progress at first being naturally slow. This work being entirely new, many experiments had to be made and methods devised to obtain satisfactory results. Then, too, my time was limited and our work had to be done after business hours. With the aid of microscopes, we found cans of spoiled goods fairly alive with microbes or germs.

Difficulty now came in making them grow outside the cans; so that the different species might be separated and the peculiarities of each be watched and studied. Many attempts were made to make them grow on different substances and in different kinds of liquid foods. The temperature favor-

able to their growth had also to be determined. Our failures were so numerous that I should have been many times tempted to drop the whole matter as impracticable, had it not been for Mr. Prescott's persistency and perseverance. However, we finally succeeded in making them grow in a modified form of nutrient agar and were enabled to separate out and obtain pure cultures of several different varieties. You may be interested to see in a way how this is done.

(Mr. Underwood here demonstrated the actual method of procedure used in obtaining pure cultures of bacteria.)

About a year after we began this work, we were enabled to find the cause and apply the remedy, some account of which we published last spring in the *Technology Quarterly*. This investigation being now well in hand, we were eager to extend our knowledge and accordingly began to work on "sour corn."

Before listening to our paper on this subject I would like to explain in a simple way about these germs, microbes or bacteria.

Germs, microbes and bacteria are used in a popular sense somewhat indiscriminately, all meaning the same thing. They are sometimes more broadly classed micro-organisms, but this term includes all small living things, such as yeasts and moulds. The general public associates the word bacteria with disease and sickness and it is very hard to dispel the idea. As a matter of fact, the percentage of disease germs to those that are harmless and those which do actual good, is very small indeed. I might liken them to our trees and plants. Very few of them are poisonous, many are harmless, and a majority are of use and benefit.

So far as we can find out, these germs, which we have found, are in no way disease-producing, any more than are those which cause milk to sour. If a person likes sour milk he will contract no disease from drinking it. Many bacteria are in the air which we are breathing at this moment. They are in the water which we drink, and in the food which we eat. The best of milk contains them in large numbers. In a teaspoonful of good sweet milk there are many thousands. So you see that bacteria, as a rule, are not to be dreaded. These germs are so very small that it is hard to convey to you an accurate idea of their minuteness; 1-20,000 of an inch does not mean much to you, yet it would be a fair sized bacillus. If our eyes were one thousand times as powerful as they are, we should just be able to see them. In form they vary somewhat. Those that we have found in spoiled goods are of two different types—micrococci and bacilli. The cocci are round like minute balls. There are different ways in which they grow. Some grow singly; some in pairs; some in long chains like a necklace; some in regular bunches of four, six or eight, and some grow in clusters like bunches of grapes. The different kinds often vary in size. The bacilli are rod-shaped and they also vary in size. Some are very short—so short that it is difficult to distinguish them from the cocci or balls. Some are very long, in proportion like a lead pencil, and they occur in different ways, very often in chains like strings of sausages.

In general their growth is very simple and is by division, each germ dividing and forming two. Under favorable conditions their growth is very rapid. Some of the rod-shaped varieties, for instance, divide every twenty minutes, and at this rate at the end of ten hours one will have multiplied to over 4,000,000,000.

To illustrate a practical evidence of this rapid growth, two cans of corn were inoculated with some of these germs and placed in an incubator at a temperature of 89 Fahrenheit about 4 o'clock one afternoon. On reaching the factory the next morning about 8 we were much astonished and dismayed to find the top of the incubator blown off, and the ceiling decorated with kernels of corn. Both cans had burst during the night, their tops being torn completely off. This pressure was caused by the fermentation and formation of gas by the rapid growth of the bacterii.

Many of the rod-shaped forms of bacilli have a peculiarity which enables them to resist heat to a great extent. These forms are called spores and they are the curse of the canning industry. When they are in this stage a boiling temperature has apparently no effect upon them, unless long continued, how long is not definitely known. We have found some that have stood a boiling temperature for eight hours and have thrived with this treatment. When seen under the highest power of the microscope many varieties of the rods or bacilli, in their ordinary active state, resemble small sausages darting and twisting in all directions. In the spore state, however, they resemble small oval beads and have no motion.

When in their normal condition microbes are easily killed at a boiling heat, and many will succumb even at a lower temperature. Most of the disease germs luckily are killed at 212 degrees or lower. It is hard to accurately determine the temperature necessary to sterilize or kill these spores as some are much more resistant than others. So far as our experience goes, 250 Fahrenheit has been sufficient, but it must be certain that whatever heat is required, it shall have reached the center of each can. We have found germs in spoiled goods, and that they are the cause of this deterioration we have proved, by inoculation; or placing these same germs into good cans, through a small hole which was immediately closed. We have thus produced the same characteristic spoiling that we originally found. To further prove that this spoiling was caused by germs alone, and not by air, we have admitted pure air, free from germs, into good cans, sealed and placed them in an incubator (at a constant temperature of 95 Fahrenheit) and for many months they have remained sound, though some of them were not opened until a year afterwards.

(Mr. Underwood here showed the method of inoculating cans and also showed cans which had been inoculated and had turned sour, and also cans into which air free from germs had been admitted and which were perfectly sweet, although they had been kept for eight months.)

There is room for a great deal of scientific work in our business; as each class of canned food probably has its germs which prey upon it, and each is affected by heat in different ways. Some work of this kind has been undertaken by one or two of our colleges, but with no tangible results.

As yet bacteriology has been but little studied from a commercial standpoint; but I think the time is not far distant when processing by the "rule of thumb," will be a thing of the past in the packing business. In Boston the Massachusetts Institute of Technology has taken up this work and is prepared to teach the scientific principles underlying the process of canning. They are now provided with retorts and all necessary apparatus under the supervision of Mr. Prescott, and I should recommend anyone having unaccountable trouble with their product, to consult with him, as the Massachusetts Institute of Technology is the only place that I am aware of that can carry on these investigations in a practical as well as scientific manner.

Throughout his discourse Mr. Underwood exhibited to the members of the convention photographs of the different forms of bacteria found in corn which have been reproduced and may be found directly following the address of Prof. Prescott. Mr. Underwood's paper was received with much applause and appreciation.

At the conclusion of Mr. Underwood's address Prof. S. C. Prescott was introduced by President Palmer.

PROFESSOR PRESCOTT'S PAPER.

In a paper read before the Society of Arts in October, 1896, we showed the extent of the canning industry in this country and the importance to it of accurate knowledge of the bacteriological principles of sterilization. In that paper we dealt with the packing of clams and lobsters, and described some of the bacteria which are active in the deterioration of these products in case sterilization is not complete. It is interesting to notice that some of the results which we published at that time have since been confirmed by a specialist employed by the Canadian Government to investigate the discoloration of canned lobsters.

We now desire to give an account of our more recent investigations in another branch of the industry, namely, the packing of sweet corn. This art constitutes a very large industry, as is shown by the fact that in 1895 seventy-two million 2-pound cans (72,000 tons) were packed in the United States.

HISTORICAL.

The growth of the art has been rapid, for it was not until about 1853 that corn was packed at all with success. Maine has been generally acknowledged as the home of corn packing, and its claim to be so considered is probably just. In 1839 Isaac Winslow began experiments in canning corn at or near Portland. He was for a long time unsuccessful. He first attempted to cook the ears of corn whole, but this proved unsatisfactory on account of their bulk, and it was also thought that the cobs absorbed the sweetness. He next tried to remove the kernels whole by means of a fork, but this was soon abandoned, and the corn was afterward cut from the cob. His first experiments were made in a common household

wash boiler, and in a very limited way. Small quantities were treated by various methods, but nearly all the corn spoiled. Some kept, however, and gave promise of ultimate success. In 1843 he built a small copper steam boiler of about two barrels capacity, and carrying ten or twelve pounds of steam. To this he connected wooden tanks lined with zinc and made steam tight. In these crude retorts he "processed" the corn, subjecting it to the direct action of live steam. Nearly the whole lot spoiled, and in consequence of this failure steam apparatus was abandoned. The next year he returned to open boilers, and continued his experiments with varying success for ten years. In 1853 he applied for a patent, but this was not allowed until 1862.

An abstract of the patent may be of interest: After a great variety of experiments I have overcome the difficulties of preserving Indian corn in the green state without drying the same, thus retaining the milk and other juices, and the full flavor of the fresh green corn until the latter is desired for use. Instead of a hard, insipid, or otherwise unpalatable article, I have finally succeeded in producing an entirely satisfactory article of manufacture, in which my invention consists. I have employed several methods of treatment. My first success was obtained by the following process: The kernels being removed from the cob were immediately packed in cans, and the latter hermetically sealed so as to prevent escape of the natural aroma of the corn, or the evaporation of the milk or other juices of the same. Then I submitted the sealed cans and their contents to boiling or steam heat for about four hours. In this way the milk and other juices of the corn are coagulated as far as may be, boiling thus preventing the putrefaction of these most easily destructible constituents. At the same time the milk is not washed away or diluted, as would be more or less the case if the kernels were mixed with water and then boiled. By this method of cooking green corn the ends of the cans are bulged out, as through putrefaction and the escape of the resultant gases had commenced within the cans. Consequently strong cans are required.

"I recommend the following method: Select a superior quality of the green corn in the green state, and remove the kernels from the cob by means of a curved or gauged knife or other suitable means. Then pack these kernels in cans and hermetically seal the latter so as to prevent the evaporation under heat or the escape of the aroma of the corn. Now expose these cans of corn to steam or boiling heat for about one hour and a half, and then puncture the cans and immediately seal the same while hot, and continue to heat for about two and one-half hours longer. Afterwards

---

*Mr. Prescott is Instructor in Biology, Massachusetts Institute of Technology, and Mr. Underwood is of the William Underwood Co., Boston.

**Technology Quarterly, Vol. X, No. 1, March, 1897, pages 183-199.

***Canadian Department of Marine and Fisheries, 29th Annual Report, Supplement No. 2, Ottawa, 1897.

the can may be slowly cooled in a room at a temperature of 70 deg. to 100 deg. F."

For nearly twenty years this method was in use, the only change being that the time of processing was shortened. About 1897 retorts were introduced in corn packing, and the second heating was done in them, the time being reduced from two and one-half hours to one. The advent of cookers about 1890 did away with the first heating in the water bath, so that now this is abandoned as an agency of sterilization. Many of the processes formerly carried on by hand are now carried on by machinery. Maine leads in the packing of sweet corn, but large quantities are packed in New York and Maryland and in the west, particularly in Iowa, Illinois and Michigan.

THE SOURING OF CANNED SWEET CORN.

Sweet corn, when properly prepared, is one of the most valuable of all canned goods, as it retains much of its original flavor, is popular, and is sold at a price within the reach of all. If, however, the sterilizing has not been done thoroughly, there may result fermentation caused by bacteria which have not been killed, producing what is known as "sour" corn. It is not definitely known when sour corn first appeared. In the experiments of Isaac Winslow, spoiling of some kind resulted, but so far as we have been able to ascertain, its nature has never been described. In a Massachusetts factory, however, where corn has been packed with success for nearly twenty years, souring suddenly occurred in 1878. Maine was also somewhat affected at the same period. Until this time corn had been processed for five hours at a boiling temperature with no loss, but in the year just mentioned, with exactly the same treatment, this manufacturer experienced a total loss. Some of this corn was sent to chemists for analysis with the hope that a remedy might be found at once. It was reported by them to be due to "fungus consisting of little globules that boiling heat did not dissolve."

Early in the following year (1879) the Massachusetts packer who owned the factory referred to attempted to continue with the old process but the corn spoiled. Retorts were procured and with their higher heat satisfactory results were obtained. For sixteen successive years he experimented with the old process with the intention of returning to it if possible. The corn so packed and kept at a temperature of 90 to 100 deg. F., invariably spoiled, swelling on the third or fourth day. It was thought that the trouble might be local, and to decide this he visited different sections, carefully selected and gathered corn, and, returning at once to the factory, packed it in the old way with the least possible delay, working sometimes all night that this might be done. The results were always the same —the corn could not be successfully packed by the old method. Had any locality been found where this could have been done, he intended to remove his factory to that neighborhood.

The exact chemical changes which take place when sour corn is produced are difficult to state, and vary under different conditions. The sugar and

starch in the corn are fermented for the most part to lactic, acetic, and butyric acid, thus giving rise to the souring. There are also other products of decomposition. Gases are frequently evolved, but being dissolved by the liquid in the can at the ordinary temperature, in the majority of cases no swelling results.

The loss resulting from sour corn during the last eight or ten years has been enormous, in some years being much more than in others. Thousands of dollars have been lost in a single year by individual manufacturers who have experienced this trouble. Moreover, the uncertainty and the possibility that losses may be incurred are constant sources of worry and uneasiness to those engaged in this industry.

DETECTION OF SPOILED CANS.

Spoiling in canned goods is generally indicated by bulging of the ends of the cans, caused by the pressure of the gases produced within. Thus a packer may generally detect any unsoundness before the goods are put upon the market, as all are overhauled and inspected before ultimate shipment. In the case of sour corn, however, at least in its first stages of deterioration, there is no outward indication of trouble. It is only under rather exceptional conditions that swelling occurs. If the temperature and other conditions are favorable for the rapid development of germs which can produce fermentation with the formation of gas, swelling will result. Since, however, the latter conditions rarely prevail in the factories, the detection of sour corn becomes difficult. Corn which is sweet when shipped may become sour many months afterward. To illustrate this fact an instance may be cited where from the same day's packing two lots of corn were shipped, one to the northern and one to the southern part of the United States. That which was sent to the north was in perfect condition at the end of the year, while that which went to the warmer climate became sour in a short time. Many instances of the same nature have been noticed by different packers, and similar results may be obtained by laboratory experiments. The explanation of this fact probably is that all the bacteria were not killed by the heating to which these cans were subjected, and that the conditions for growth of the micro-organisms became favorable only in the warmer locality. Provided sterilization is not complete, there seems little reason to doubt that climatic condition is a most important factor in the souring of corn. It should always be borne in mind that if processing or sterilization is complete sour corn cannot result, because the germs of fermentation are destroyed. When souring occurs the percentage of bad cans may be small, but often runs from 10 to 40 per cent., or even higher. Such goods are generally returned, and an attempt is made to separate the sweet from the sour cans. To do this there are two methods in common use.

According to the first method, the cans are put into a tank of water at a temperature of 80 deg. F., where they stand for from six to twelve hours in order that the contents may be heated uniformly throughout. They

are then removed and their ends just submerged in water at 190 deg. F. Here they remain for not more than thirteen minutes. At the end of that time those cans which are swelled are rejected as sour. The other method is to boil the cans for one hour. This causes all the ends to bulge. They are then cooled, and those whose ends remain bulged for more than eight hours are rejected, while those which "snap back" within this time are considered satisfactory. Both these methods depend for their success upon the fact that at certain temperatures gas is produced rapidly by bacteria within the cans.

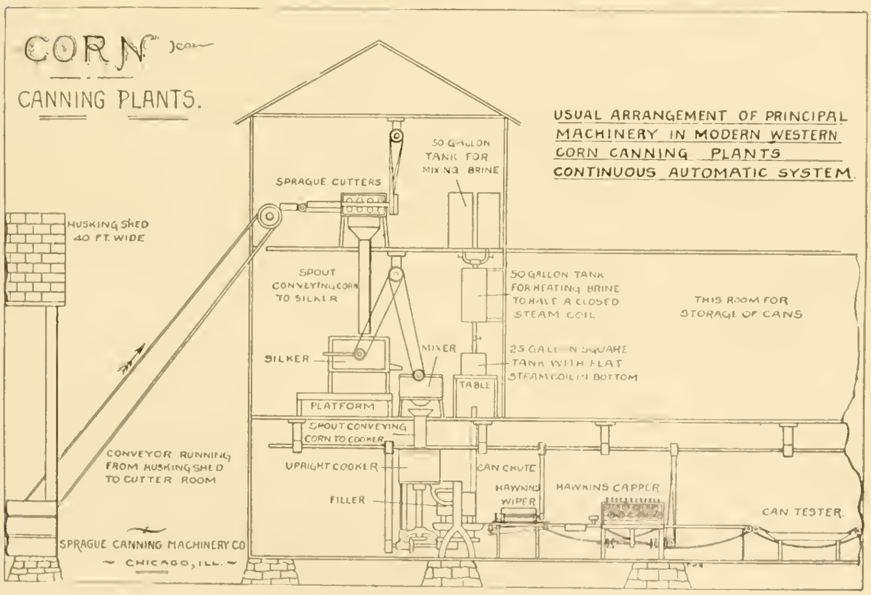
BACTERIOLOGY OF SOUR CORN.

Our investigations commenced in February, 1897, with the examination of a large number of cans of sour corn. On opening the cans no change was noticeable to the eye, the corn appearing fresh and of a natural color. In some cases a sour odor could be detected, but in others this was not observed. It was to the taste that the trouble was most apparent, the corn being sour and of a peculiar astringent quality. Bacteriological examination showed sound cans to be sterile, while spoiled cans invariably gave evidence of bacterial action. Pure cultures of twelve species of bacteria were obtained, of which eleven were bacilli, and one was a micrococcus. It must not be supposed that these bacteria are disease-producing; they probably act merely upon the saccharine and starchy matter, transforming it to organic acids and other substances of more or less disagreeable taste and odor, and make the corn unpalatable and destroy its commercial value.

By inoculating sterile cans of corn with these organisms we have been able to produce souring in all respects similar to that of the spoiled cans from which they were originally taken. Our experiments were conducted in the laboratory in the following manner: A number of cans were selected and all of them were punctured, this operation being done in a sterile glass chamber. A part of the cans were inoculated with cultures obtained from sour corn, and all the cans were then sealed and put in an incubator kept at the blood heat. The cans which had been inoculated commenced to swell in from twelve to twenty-four hours, while those not inoculated remained as sound as when put in the incubator. Thus we easily proved that a vacuum is not necessary for keeping canned corn, and that air may be admitted to a sound can and spoiling will not result, provided proper precautions are taken that the air so admitted be free from germs. This statement will undoubtedly be regarded with incredulity in some quarters, so strong is the popular belief among packers in the indispensability of a vacuum, yet a long line of experiments from the days of Tyndall to the present time prove the validity of this assertion. Moreover, there are bacteria which can develop in a vacuum, and which could find favorable conditions within cans from which the air has been expelled. Sterilization, not the driving out of air, is the important factor in keeping all kinds of canned goods; and although, as we have shown in our earlier paper, the vacuum is necessary in testing

the cans, no preserving power can be ascribed to it. These experiments have been made repeatedly, and always with the result that souring takes place when living bacteria are present. The presence and activity of the bacteria in sour corn have also been shown by inoculating various kinds of culture media with material from spoiled cans. Active fermentations, of the various kinds previously mentioned, have been brought about in this way.

In order to study these fermentations more thoroughly, and to ascertain, if possible, the source of the bacteria causing them, we spent nearly the whole of the corn-packing season of 1897 at an establishment in Oxford County, Maine, where every convenience for scientific study of the process was kindly put at our disposal by the proprietors. We were thus enabled to investigate thoroughly the methods of procedure, from the harvesting of the green corn to its ultimate shipment in cans.



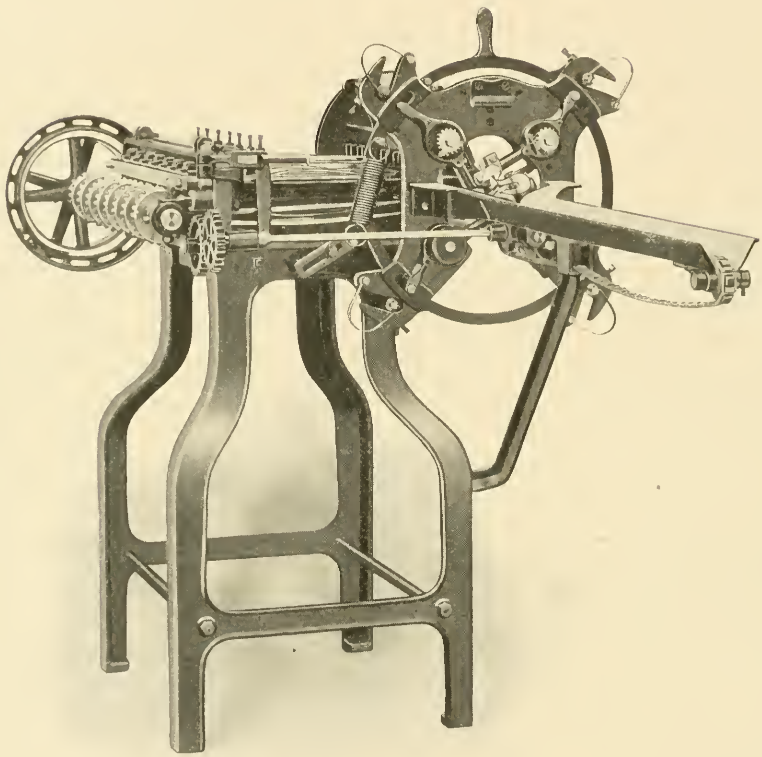
THE PROCESS OF PACKING CORN.

It is very important that the utmost cleanliness and dispatch should be observed in all the operations, so that the chances of infection from bacteria may be reduced to a minimum. In this factory the strictest caution was exercised in these respects, everything being kept scrupulously clean. The corn is generally picked in the morning, and is delivered to the cannery as early as possible. One or two men make it their special duty to visit the farms once or twice a week during the season to keep informed as to the condition of the crop, and to "order in" the corn as it becomes sufficiently matured. As the ears are delivered at the factory they are arranged in low piles on the ground in an open shed to protect them from the sun. The husks and silk are taken off by hand, and the corn is then quickly carried to the cutting machines, in which, by a series of knives and scrapers, the kernels are quickly and cleanly separated from the cob. Any stray bits of cob or silk which may be mixed with the corn are now taken out as it passes through the "silker," a machine arranged somewhat on the plan of a gravel-sifter; that is, with two cylindrical wire screens one inside the other, placed on an incline, and rotating in opposite directions. The corn drops through the meshes of the screens, while the refuse passes out at the lower (open) end.

The corn is now weighed, mixed with water in the proper proportions and is then ready for the cooker. There are several varieties of these machines in use, all of which are alike in principle, but differ somewhat in the details of construction. Their object is to heat the corn evenly and quickly to a temperature of 82-88 deg. C. (180-190 F.), and to deliver it automatically into the cans. A single machine fills about thirty cans a minute. The duty of the cooker is threefold: First, in the heating to which the corn is here subjected some of the bacteria, particularly those in the vegetative state, are killed. Second, the corn being filled into the cans while hot expands the air, so that after sealing and cooling a partial vacuum is produced, which, as before stated, is essential for the detection of unsound cans. Finally, this cooking heats the corn to such a temperature that the subsequent sterilization in the retorts is brought about more quickly, and the danger of browning or scorching of the corn next to the tin is minimized.

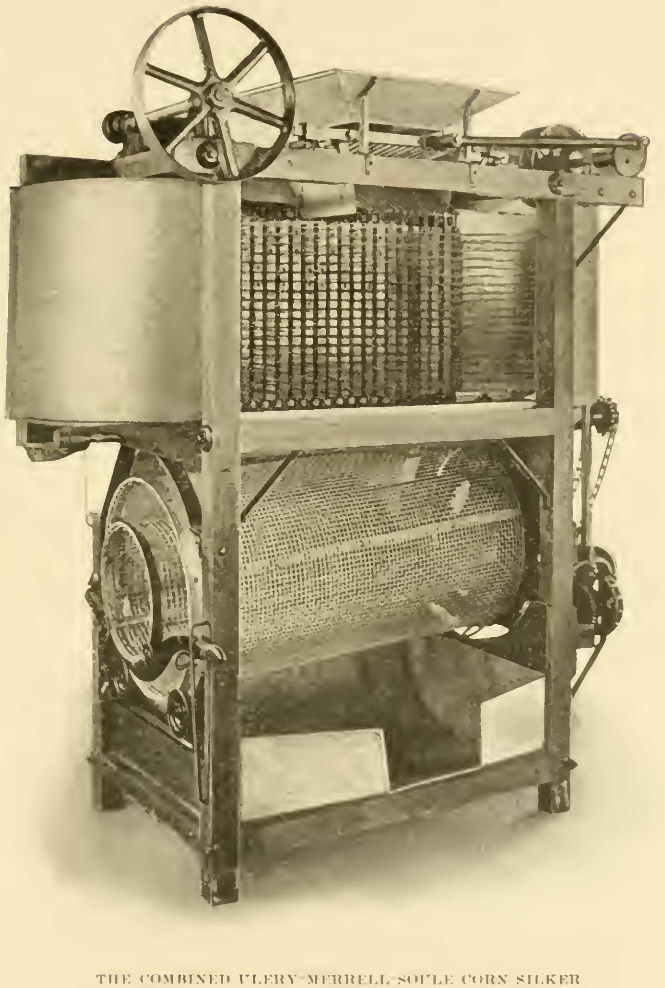
The cans are next capped, soldered, and tested for leaks. Sterilization, the final and most important step in the whole process, now follows, and is done in retorts, by steam under pressure. The length of heating or processing, and the pressure which is given, vary somewhat in different factories. As we have shown in our previous paper, in practice, in order to insure sterilization it is necessary to obtain and maintain a temperature in excess of 100 deg. C. (212 deg. F.) throughout the contents of the can and for a period of time varying with the substance to be sterilized.

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.



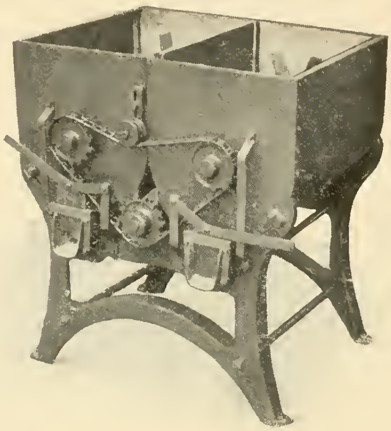
THE SPRAGUE CORN CUTTER (LATEST IMPROVED. MODEL M)

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.

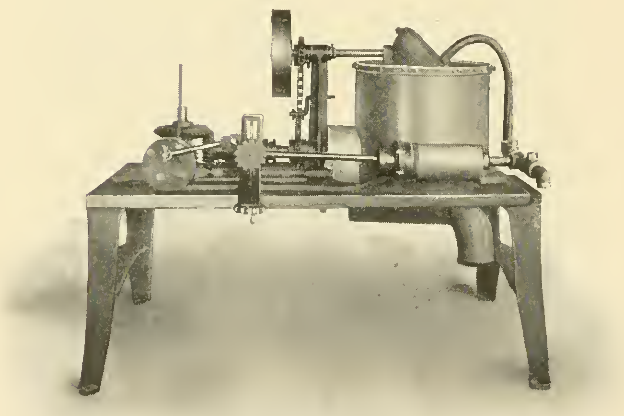


THE COMBINED ULERY-MERRELL-SOULE CORN SILKER

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.

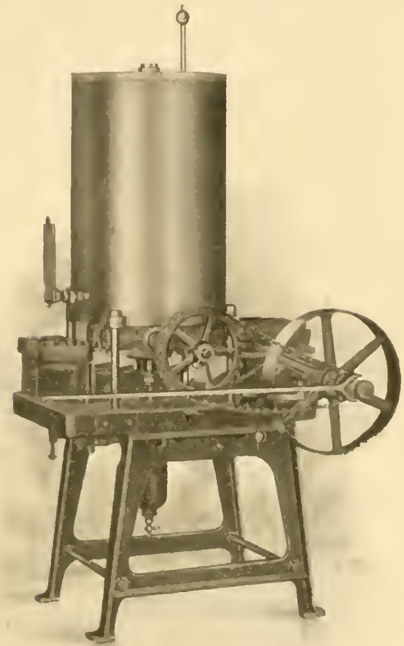


THE MERRELL-SOULE DOUBLE CORN MIXER

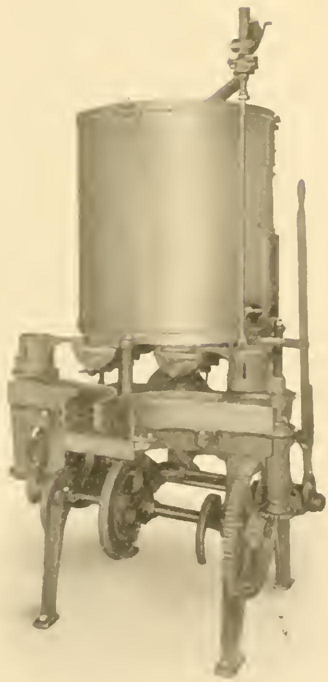


THE CUYKENDAL CORN MIXER (COMBINED MIXER AND FEEDER)

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.

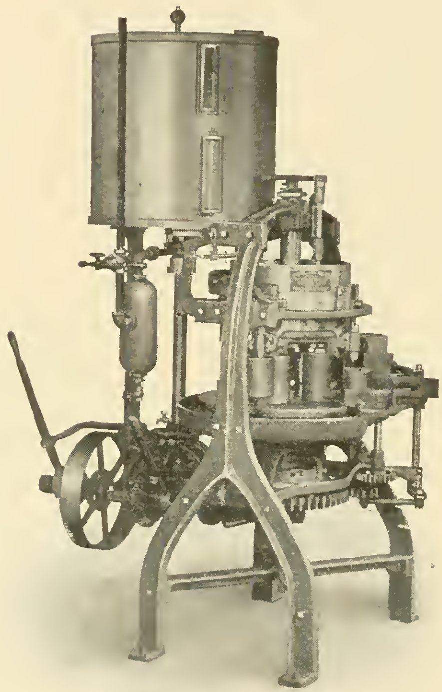


THE BURNHAM CORN COOKER FILLER

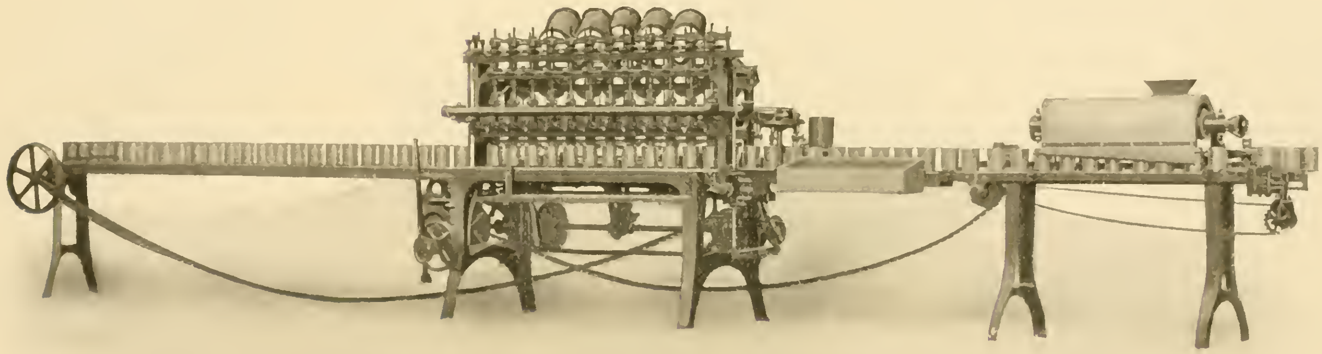


THE CONANT CORN COOKER FILLER

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.

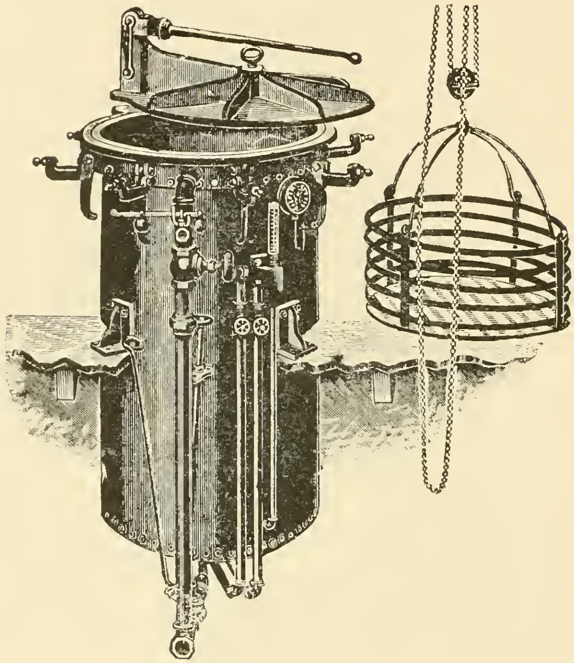


MERRELL-SOULE CORN COOKER-FILLER



THE HAWKINS CAPPING MACHINE (COMBINED WIPING AND CAPPING MACHINE)

Modern canning machinery used in the process of packing green corn as mentioned in Professor Prescott's paper.



THE WEST UPRIGHT PRESSURE PROCESS KETTLE OR RETORT

METHOD OF STERILIZATION.

It is thought by some that intermittent sterilization might be employed in packing, but we consider this entirely impracticable upon a commercial scale. Intermittent sterilzation consists in heating to the temperature of boiling water for a length of time varying from thirty minutes to one hour, on three or four successive days, the substance to be sterilized being cooled and kept cool between the heatings. It is supposed that in the first heating all the active bacteria, the so-called vegetative cells, are killed, while the more resistant forms, spores, retain their vitality. According to the theory, the majority of the spores germinate and become active before second heating, and in turn are killed, while by the third heating all the remaining spores will have developed into active bacteria, and will then be destroyed.

To insure success by this method of sterilization, apparatus and means must be employed which, while practicable in a small way, are in our opinion absolutely impracticable on such extensive scale as would be demanded commercially. To use this method would necessitate at least three times as much sterilizing apparatus, much more room, a greater amount of labor, and a great loss of time.

To show the resistance of bacteria to the continuous action of a boiling temperature, we have found that certain species isolated from sour corn will survive actual boiling for more than five hours, and other species of bacteria which are met with in spoiled canned goods have been boiled for eight hours without being killed. These facts serve to show conclusively the impracticability of the ordinary water bath. On the other hand, the retort with its high temperature will, if properly used, kill all forms of bacteria at a single heating, without injury to the food substance, the length of time required varying, as has already been said, with the conductivity of the medium for heat. We have found by experiment that sixty minutes at 121 deg. C. (250 deg. F.), as indicated by the thermometer on the outside of the retort, is sufficient time for sterilizing corn in two-pound cans, and it seems probable that this can be shortened somewhat, or the temperature reduced. Further experiments are in progress to decide this question.

WHITENESS OF CANNED CORN.

Through a demand that canned corn shall be very light in color, there has been, apparently, a pressure put upon the packer to shorten the time of heating or to reduce the temperature in his retorts. The large losses which have resulted in recent years from sour corn have, it is claimed, been due principally to this demand. Instances are known where the desired result has been brought about by some bleaching reagent, generally sulphite of sodium. While this may not be unwholesome, it greatly injures the flavor of the corn, as a comparison of such corn with that without bleachers will show. Although such cases sometimes occur, it cannot be said to be the fault of the packer; for if the dealers demand very white corn the packer must resort to some unusual means in order to render his product salable. In this connection a statement in a recent trade journal is noteworthy: "The volume of poor corn which has found its way to market in the last few years has had, and is still having, a considerable effect upon the consumption of that article, and there are a good many families who never buy canned corn nowadays because they have found little but disappointment in their corn purchases of the last few years."

It is much to be doubted if the consumer demands that the corn be very white in color. What he desires is a palatable article with a natural flavor. It seems evident that in the near future the dealers must regard this very white corn with disfavor, and reject any in this condition.

MAXIMUM TEMPERATURE WITHIN THE CANS.

By the use of small registering thermometers which can be sealed up within the cans, and which record the maximum temperature reached, we proved, in an extended study of the process as it is actually carried on at the factory, that corn is a very poor conductor of heat, and that the time necessary to bring all portions of the center of the can to the requisite temperature is a factor whose importance cannot be overestimated. Corn as it comes in cans from the cooker is at a temperature of 82 to 88 deg. C. (180 to 190 F.). At the end of thirty minutes in a retort with a pressure of thirteen pounds, the corresponding temperature of which is 118.8 deg. C. (246 deg. F.), a thermometer in the center of a can placed in the middle of the retort, which was full of corn, registered 108.3 deg. C. (227 deg. F.). At the end of forty-five minutes, under the same conditions a temperature of 114 deg. C. (237.2 deg. F.) was reached and at the end of fifty-five minutes the retort temperature of 118.8 deg. C. (246 F.) was registered by

---

*Canner and Dried Fruit Packer, Vol. V, No. 19.

the thermometer in the can. From this it is evident that if a packer were giving his corn an hour in the retort at this pressure, the central portions of the can would in reality be subjected to the full effect of the heat for only five minutes. Thus it is evident that with the present methods any reduction of time of heating is attended by considerable risk. If any means could be devised by which the heat could reach more quickly the center of the cans, it might be safe to shorten the time of heating. There is a prospect that before long such modifications may be possible.

BACTERIOLOGY OF SWEET CORN.

The source of the bacteria producing the fermentations described was also a problem, the solution of which we sought with great care. Every step of the process was investigated bacteriologically, and all channels of infection, the water supply for example, were studied. The general cleanliness and the liberal use of water and steam throughout the factory which we visited reduced the liability of infection from dust to a minimum. We examined the green corn on the cob, the corn as it came from the cutting machines, as it went to the cooker, as it came from the cooker, and as it came from the retorts after the usual processing and after some periods of heating given for experimental purposes. Living bacteria were found on the raw corn, and at all stages of the process before the final sterilization. the corn as it went to the cooker was found to contain many germs, but in the short heating to which it was subjected there, some of the organisms were destroyed. Cans which had been retorted for thirty minutes or less were found to contain living bacteria, and cans so treated spoiled and became much distended within four days. No living bacteria were found in cans which had received the full time of processing at this factory. By culture methods and by microscopical examination we have found that the bacteria living upon the kernels of corn and those which we found in the later stages of the process are undoubtedly of the same species. They all correspond in all respects with species which we obtained from cans of sour corn in the laboratory experiments carried on in the early part of our investigations.

All these organisms are characterized by great rapidity of growth when allowed to develop at a temperature of 37 deg. C. (98.60 deg. F.). In evidence of this fact we need only to state that of the large number of cans incubated at this temperature many swelled within twenty-four hours, while in several cases the cans exploded within that time. Agar streak-cultures of these bacteria frequently showed well-marked growth within six hours, and in some cases in four hours. The growth is much retarded at a temperature of 20 deg. C. (70 deg. F.). None of the organisms which we have obtained correspond closely to the published descriptions of lactic or butyric acid organisms, or that of the Bacillus maidis of Cuboni.

If sour corn is the result of bacterial action, the question naturally arises, Why should a packer have trouble in a certain year, when he is using pre-

sumably the same methods of treatment that he has employed without loss in former years? A number of conditions might exist that would account for this. In the first place, it is a well-known fact that diseases which are caused by bacteria may be much more prevalent in some years than in others. The same is probably true in the case of the bacteria which attack corn. The weather may be much more favorable for the growth of these germs in certain years than in others, and there is good reason to believe that a warm moist season is more apt to give sour corn than a cool dry one. Is the packer entirely sure that the conditions prevailing in the factory are always the same from year to year? Other things being equal, if exactly the same methods are used, similar results should be obtained. But to all outward appearances the conditions may be the same, when in reality they are quite different. Differences in the steam gauges or thermometers, or a little carelessness on the part of some operative, may be sufficient to turn the scale and give rise to sour corn where before none had existed. That trouble might be caused by such slightly changed conditions can be seen readily when we realize that, as we have already shown, it is being processed in the retort for an hour at a temperature of 240 deg. C., or over, the corn at the center of the can is in reality only receiving this intensity of heat for five minutes.

Believing that, in order to be of practical value, all laboratory experiments must be carried on under conditions as nearly as possible like those existing in the factory, we have recorded only such results as have been obtained under these conditions. There are still some facts to be determined which can not be settled by laboratory experimentation, and which, owing to the shortness of the packing season, we were unable to push to completeness last year. We hope another year to investigate these points more fully.

We wish to express our gratitude and indebtedness to all those who have so kindly helped us, and particularly to Prof. Sedgwick, without whose cooperation this work would have been long delayed.

In conclusion we would again affirm:

1. That sour corn appears to be always the result of bacterial action, and due to imperfect sterilization.

2. That in case of insufficient processing souring does not always result unless the cans are subjected to conditions favorable to the growth of the bacteria within.

3. That the bacteria which produce sour corn are found on the kernels and beneath the husks of the corn as it comes from the field.

4. That the bacteria found on the ears of corn correspond in all respects to those originally found by us in cans of sour corn.

5. That swelling may be caused by bacteria other than those which produce sour corn, but it is always a natural consequence and a further development of this process of souring, provided the cans be subjected to a favorable temperature.

6. That so far as we have been able to discover, the organisms present

in sour corn are capable of producing serious commercial damage and an unpleasant taste, but are otherwise harmless.

7. That a vacuum is not necessary for the preservation of canned goods, but is a valuable factor in the detection of unsound cans.

8. That the use of bleachers is not to be recommended, and is unnecessary if proper methods of sterilization be employed.

9. That the utmost cleanliness at every step is absolutely essential.

10. That intermittent sterilization is not practicable on a commercial scale.

11. That the open water bath is inefficient as a means of sterilization.

12. That with the present methods of retorting it takes fifty-five minutes for the temperature which is indicated on the outside thermometer to be registered at the center of a two-pound can of corn previously heated in the cooker to 82 to 88 degrees C. (180 to 190 degrees F.).

13. That heating for ten minutes with a temperature of 126 degrees C. (250 degrees F.) throughout the whole contents of such a can of sweet corn appears to be sufficient to produce perfect sterilization.

Following the addresses members were requested to ask any questions regarding the subject which interested them. This opportunity was eagerly taken advantage of and many important points were brought out. The discussion being in every way pertinent to the subject, it is incorporated with the article:

Mr. Bunting: Mr. Chairman, I would like to ask the gentlemen for the information of those present, when, in his opinion, bacteria take possession of corn. Of course, corn as it is plucked from the stalk must be in a healthy condition, and when it is husked it must be in its active, healthy condition. Now, sir, when, in your opinion, does bacteria make its first appearance to the detriment of the corn; is it at the time the corn undergoes the cutting process and the milk is thereby exposed to the atmosphere, or is it prior to that time?

Mr. Prescott: That is a hard matter to state, when they get there. You take the healthiest ear of corn that you can cut and subject the kernels to a bacteriological examination, you will find that in that case the kernels of corn have bacteria on them. When they get in I don't know. The seal of the husks, you know, is not absolute, and it may be that they are carried by moisture, and it may be that they follow down the silk and get in in that way. I think they are there probably all the time from the beginning of the development of the corn kernel. We do not only find these things in corn, but also in grain, in wheat.

Mr. Bunting: When do they produce this? When does the souring take place?

Mr. Prescott: That will take place in case the corn is packed rapidly, in case the heat in the matter of process is not strong enough to kill the spores. The spores have a formation resembling two husks, and when in this condition the spores rapidly shed one of the husks. They are covered by two coatings practically impervious to heat. Under favorable conditions they shed these coats rapidly and get into a vegetative form and then the develop-

ment is indeed very rapid. You put vegetative forms of these spores in corn and it will surely produce some souring.

Mr. Black Did you make experiments with a less degree of heat than 250 degrees?

Mr. Prescott: We have made some experiments, but perhaps not so many as would be necessary to get an absolute figure as to what temperature would be sufficient.

Mr. Black: I understand corn is being processed all the way from 230 to 250 degrees. Would anything less than 250 save the corn?

Mr. Prescott: As you diminish the temperature you must increase the length of time of the heating. Our experiments indicate that corn is such a poor conductor of heat that in many cases, unless subjected to the limit or the time is increased, the temperature does not penetrate into the center of the can rapidly. Fifty-five minutes would be about the time necessary for the corn to be in the retort before the heat would penetrate to the center of the can. You cannot reduce the temperature unless you increase the length of time of the heating. The safest process would be with a heat of 250 degrees. The outer cans have a little freer access to the steam than those in the center.

Mr. Black: Does that apply to dry steam or water process?

Mr. Prescott: That is dry steam .

Mr. Black: Would not it be any different in water process?

Mr. Prescott: I should not suppose so.

Mr. Bunting: The papers to which we have listened certainly must have proved interesting to all of us. We are all interested in the packing of corn. I am reminded by these papers of an accident which befell a friend of mine when packing in a shed a lot of corn green, it swelled and raised the roof off of the shed. These papers certainly have been interesting as well as instructive, and I move that this convention extend to these gentlemen who have entertained us this morning a vote of thanks.

By the President: I want to say, before putting this motion, that the work of these gentlemen has been a work of love. While Mr. Underwood is a packer, he does not pack corn, and he has pursued these investigations merely from the pleasure of it, and in the hope that it would do somebody some good.

(Motion put by the chair; carried.)

By a Member: What effect has artificial preservatives upon bacteria?

Mr. Underwood: It would have the effect of killing them, but it would be detrimental to the corn. We can kill all these things by heat. There is no need of using any preservative so far as that goes, in any canned goods. It should not be done, and it is not needed. I would like to state here that we have some cans of corn which we have inoculated and some which have not been inoculated. We should be glad to open these cans. We think we have some corn here that is sour in some of the cans in which the corn has been inoculated and kept in an incubator, and some that has not been kept there. Any questions you might desire to ask we would be glad to answer.

Mr. Polk: Did you investigate to determine whether the corn would get darker by processing it at a degree of 240 ten minutes longer, than it would at the required time at 250?

Mr. Underwood: It is rather hard to determine that. Every minute you add tends to darken the corn, and also every degree of heat. I don't just exactly get your question.

Mr. Polk: I wish to know if it would become more dark to process it say ten minutes at 250 degrees than it would say twenty minutes at 240?

Mr. Underwood: We haven't made any direct experiments on that subject. I think the lesser time at 250 would darken it a little.

Mr. Polk: Would different localities have an effect? For instance, in the west it requires a different cook than in the east.

Mr. Underwood: I think that might be so. In the west you have warm weather. The way for the packer to do is to consider that the germs are in the cans and to make their retort time sufficient to kill them. It can be done easily. I understand there is to be a retort gotten up whereby the cans be subjected to the same degree of heat, and that heat will reach every portion of the can and the time can be shortened greatly from what it is now. If you give it a long enough time to get to the center of the can you are liable to scorch the corn near the outside of the can.

Question: What would be the difference between a dry retort and moist retort?

Mr. Underwood: Our experiments have all been with the dry retort. The more water you put in the can the quicker the heat will go through it, and the less water you put in and the more dry corn in, the harder to get heat into it.

Delegate from Nebraska: If all the corn got a heat of 250 degrees for ten minutes, would that be sufficient?

Mr. Underwood: Yes.

Delegate from Nebraska: How long would it have to be kept at 240?

Mr. Underwood: We haven't determined that yet. For instance, a can of soup could be processed in a very few minutes, because it is all water.

Mr. Palmer: If the corn is packed very dry without any water at all the germs will not develop as much as if there was water in it.

Mr. Underwood: Germs will develop much faster in moisture than in dryness.

Question: From your experience, what is the minimum degree of heat that will kill these germs?

Mr. Underwood: We will state that 250 degrees will do it. Somewhere between 212 and 250. The safety line may be between 250 and 212. We feel very certain that 250 is sufficient.

Question: From what you have explained I should infer that a short hot dip would be much better than a longer one?

Mr. Underwood: Very much.

Question: I should infer from what you have stated that these spores develop under an increased degree of heat quicker than in the natural tem-

perature, and it is from the development of the spores that the trouble comes?

Mr. Underwood: Bacteria develop very much faster at the temperature of blood heat than they do at a lower temperature. Corn from one of the biggest packing houses was shipped, some of it south and some of it north. That that went south soured and that that went north did not. The reason for that is that these cans were not all placed under the same condition, some having gone to a warm climate and some to a cold.

Question: Are you satisfied that fifty-five minutes in a retort at 250 degrees, that corn can be cooled down at once?

Mr. Underwood: I think that would be dangerous because it takes fifty-five minutes to get that heat there. The quicker corn is cooled after it is thoroughly processed the better, Fifty-five minutes at 250 degrees will thoroughly cook it. I think that is the danger line. You must understand we are not corn packers.

Question: You contend that all corn contains bacteria?

Mr. Underwood: Yes.

Question: Is it due to the acid in tomatoes that it is easier to save tomatoes than it is corn?

Mr. Underwood: That is something we don't know anything about. Tomato is a liquid and the heat gets into the center of the can in a short time.

Question: Would you advise the use of lime scattered around the factory?

Mr. Underwood: I think it would be a good idea; and another thing I think would be a good idea is, and it is carried on in the factory where we were working making our experiments; the cobs were taken away every night. As soon as they begin to ferment the air becomes full of germs and they are more liable to get into the goods.

Mr. Bunting: What have you to say about brown corn, corn taken out of cook and allowed to cool without being submerged in water, is it more liable to become brown at one end?

Mr. Underwood: I think that would be a very natural condition. If you do not cool the corn the cooking is still going on. I have often noticed that the center of a can of corn is whiter than the outside.

By a Member: Has the addition of sugar any bearing on the question of souring?

Mr. Prescott: Cane sugar is not generally acted upon very rapidly by bacteria, so it does not seem that the addition of sugar would make any great difference. There is no reason to think that the souring is due to the presence of sugar in the corn. It does not seem to me that the souring would would take place any more quickly.

By a Member: Would the heat of 250 degrees Fahrenheit have any effect on the spores in the corn?

Mr. Underwood: It would kill them.

Mr. Moore: I have known some packers of corn to have had one-quar-

ter of the pack sour without swelling and the other be all right. How can that be accounted for?

Mr. Underwood: Did the souring all occur in one place?

Mr. Moore: Yes, it ran through the whole pack. It did not come out of the retort at the same time.

Mr. Underwood: Some packers use thermometers which are not at all fit to be used. Their steam gauges are often not right. Your thermometer must be thoroughly tested, that you must see to yourself. You don't know just what your men have done. Processing is the most important part in canning goods. If the thermometers are not exactly right your goods will not receive the proper process.

The President: I think there is another explanation, and that is, every can of corn does not have the same amount of water put into it. Some cans are dryer than others and it might take longer for the heat to get into the center of the cans.

Mr. Underwood: That is so; if everything is not just right, owing to the short time given to the processing, something wrong may occur.

Mr. Bunting: Have you struck upon any plan whereby you can bring to light sour corn or peas that do not indicate their character on the surface of the cans and yet the conents are sour, a most vicious condition of things, of course; have you struck on any plan whereby you can detect sourness in these cases so they may be thrown out? We have given two methods for detecting those things.

Mr. Underwood: If the right temperature is maintained there is no need of that. I think if we process our goods with the idea that the spores are naturally there there will be no trouble. There is a way in which that might be done. In our experiments we have used an incubator and placed these cans in there. If a packer could fix up a room whereby he could maintain a blood heat he could put in three portions of his pack every day and in the course of two or three days the sourness would be indicated by swelling. In years gone by my grandfather who packed and sold meat to the United States Government during the war of the rebellion had a room that he put his goods in; he put in part of his goods every day and in that way saw they were right before they were sent out. Something of that kind might be arranged in regard to the corn.

By a Member: Supposing we had a lot of corn that contained a percentage of five or ten per cent of souring, would it be possible to subject that corn to 250 degrees to prevent any farther fermentation?

Mr. Underwood: It would stop those that were souring, but it would not turn those that had soured back into sweet corn.

By a Member: Before sending them out, knowing there was a small percentage, would it be safe, or could you save the balance by subjecting it to a temperature of 250?

Mr. Underwood: Yes; but it would have a tendency to darken the goods. You could overcome that by boiling them first.

Mr. Bunting: What effect has temperature upon corn? Now, we know, all of us, that the best corn ever packed in this country was packed years ago

when they used to pack it under a low temperature and cook it a long time, four or five hours. In those times you never used to hear of sour corn or dark colored corn. What effect has the pressure in the boilers on the cook of the corn?

Mr. Underwood: It is not the pressure, but the extra heat that is developed by the pressure.

Question: Have you done any experiments with corn that has been carried a long distance and piled underneath the shed, as to whether or not that would increase the growth of germs?

Mr. Underwood: We didn't try it, but it would naturally be so.

The same Member: My only experience is that our loss has been greater from that source. Can this be killed by an increased heat?

Mr. Underwood: Yes, at 250. I don't think there is any doubt about it. I would recommend treating corn of that kind to an increased heat.

By a Member: In carrying this heat would it be just as effective to carry 240 degrees for fifty minutes and the last ten minutes 250 degrees?

Mr. Underwood: I couldn't say that. I think it would be necessary to carry it clear through.

The President: Did you make any experiments with corn in different conditions? With corn that is very young and corn that has become hardened, to see whether the bacteria was present?

Mr. Underwood: No, sir; we haven't done that. We are going to do it another year. We did the most important things this last year.

By a Member: Can you tell us why, since we have used bleachers for eight or ten years without having any trouble, it begins to turn our corn black?

Mr. Prescott: Have you made any change in the use of your plate?

Question: We began using American tin about the same time that the change took place. We have investigated along that line, but it was determined by the chemists that that was not the cause.

Mr. Prescott: If there is any difference in the quality of the plate the action of the sulphite of sodium on the iron would cause it. If the tin was off of the plate in any little place the chemical action of sodium on the iron would turn the corn black.

Question: I have heard of this sulphide of sodium being used for some years, and have used it. A few years ago we had some trouble and I went back home and took an oath that I wouldn't use another grain of it, and I didn't use it, and the next year I had worse corn and more black spots than I had the year before. The sulphide had nothing to do with it. The goods were worse that year than they were the year before, and I used nothing but salt and water in my corn. This was just about the time that I understood that Europe had sent to this country many boxes of tin and our home packers bought a lot of it at a cheap price and I came to the conclusion that the tin was so lightly on the plate that the acid in the corn caused these black spots.

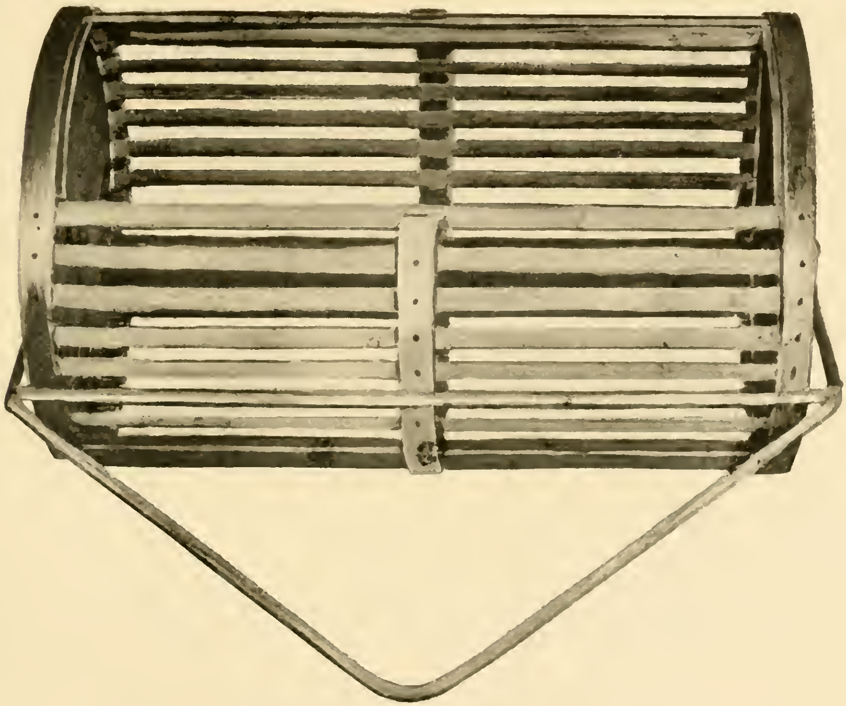
Mr. Prescott: Are the spots scatttered all through the corn?

Question: Sometimes at the bottom, sometimes sifted all through, and sometimes in streaks.

Mr. Prescott: Do you get it in the interior of the can?

Question: No, sir.

The President: I would like to make a statement in regard to the plate, and that is in late years they have been using less tin upon the plates than they used before, in fact, they use as little as they can. It is a fact now that tin plate makers in this country as well as in Wales are using in many cases two pounds of tin to make a box of 100 pounds of plate. Of course, that is not good plate and I have no doubt that the black spots may come from the action of the corn on the steel.



REVOLVING CRATE OF THE AUTOMATIC CALCIUM SYSTEM (PATENTED)

After attending the convention at which this paper was read, John C. Winters of Mount Morris, N. Y., commenced a series of experiments with the aim of improving the methods of processing to insure more uniform results in sterilizing and developed and perfected the automatic calcium processing apparatus (patented), described on opposite page which not only reduces the cost of packing but removes to a very large extent the risk of souring spoilage and waste which occur in processing with kettles and retorts.

THE AUTOMATIC CALCIUM PROCESSING SYSTEM

(Patented)

referred to on preceding page, takes the place of pressure process kettles and steam chests, for processing goods which require temperature above 212 degrees Fahrenheit.

It is claimed for this system that it reduces labor; saves steam; gives an absolutely uniform cook to every can of goods; produces better results in color of corn and does away with all work connected with timing kettles. The contents of each can changes position repeatedly during the cook, thus insuring more uniform treatment.

The System consists of a substantial boiler iron tank about 4½ feet wide, 4 feet deep and one foot in length for each thousand cans to be processed in ten hours. Above this tank is a support for endless chain trolley system, which carries hooks for engaging and dragging a cylindrical revolving crate through a bath containing calcium in solution, heated by steam. Any temperature required (250 degrees in running corn) can be secured and uniformly maintained. The manner of operating this system is as follows:

The Crate has a hinged gate opening along one side, into which the cans may drop directly from the discharge end of capping machine. At each end of the tank is a convenient power hoist. One operator hoists each crate as filled and hooks it onto the conveyer hooks. It then goes into and through the tank, the crate revolving as it is dragged slowly along by the carrier mechanism, which is set at desired speed, driven by a separate engine, furnished with the system for this purpose. When the crate emerges from the far end of tank an operator takes it with hook of power hoist, releasing it from the carrier hook, and lowers the crate into a small tank filled with constantly changing cold water. This rinses the can of the calcium. The processing is then complete. After rinsing, the hoist conveys the crate at right angles a few feet and it is there transferred to a second trolley system and is carried revolving through a second tank containing cold water. This tank is parallel to the cooking tank and its carrier driven from same movement as that of the processing tank. The cans are usually packed directly into canned goods boxes after they are dumped from the crate.

With this system one foreman and three cheap hands is all the labor required to process and cool up to 80,000 cans in ten hours.

DESCRIPTIONS OF BACTERIA

As Found by Professor Prescott and W. Lyman Underwood and Explained in Previous Chapters.

Bacillus A.

Found in Cans of Sour Corn.

General characters: Shape and arrangement, bacillus, occurring singly and in short chains. Size: Generally 2-4u long by 1u broad. Many cells are very long, and vary from 10-50u in length. Motility: Rapid serpentine and spinning movements. Relation to temperature: Develops at 37½ deg. C.; more slowly at 20 deg. C. Relation to air: Aerobe and facultative anaerobe. Relation to gelatin: Liquefies. Color: Non-chromogenic. Gelatin: Stick culture; develops rapidly throughout whole length of puncture. Liquefaction begins within twenty-four hours, and at the end of two days a horn-shaped liquefied portion is observed. Plate culture: Surface colonies, very small. Liquefaction begins almost as soon as colonies are visible; in two days

Plate Culture, Showing Colonies of Bacillus U.
Found under husks of green corn.

the plate culture is entirely liquid. Submerged colonies, apparently same as on surface. Agar: Streak culture: A thin, smooth layer, covering nearly the whole surface. Edges dissected and bluish in color. In two days lower part of culture becomes dryer, white and finely wrinkled. Plate culture: Surface colonies: Vary much in size and shape. Young colonies are very small, oval or circular. Spreading soon begins, giving irregularly branched or sullate colonies. Submerged colonies: Very small, oval or spherical. Potato: Potato much darkened. A thin film of growth covers the surface. This film is at first moist, but at the end of three days dry and finely wrinkled. Milk: Not coagulated. Acidity, strong. Smith Solution: No gas produced. Thin film on surface. Sediment at bend of tube. Turbid throughout.

Strongly acid. Nitrate. Is reduced to nitrite solution clear. Bouillon: Slightly turbid at end of twenty-four hours at room temperature. Film develops in twenty-four hours in incubator at 37½ deg. No sediment.

Bacillus B.

General characters: Shape and arrangement: Bacilli, occurring singly and in short chains. Spore formation: Very small oval spores. Relation to temperature: Develop more rapidly at 37½ deg. C. than at 20 deg. C. Relation to air: Aerobic, facultatively anaerobic. Relation to gelatin: Liquefy slowly. Color: Non-chromogenic, Gelatin: Stick culture: Growth well marked entire length of line of inoculation. A small cup-shaped depression is observed on second day. This increases in size as liquefaction occurs.

Plate culture: Surface colonies: First appear as small translucent blue dots, which later become white or gray, and slowly liquefy the plate. Colonies from 1-8 inch to 3-16 inch in diameter. Submerged colonies: Small and blue when seen by

Bacillus U. Vegetative State From Bouillon.
Magnified 1,000 Times.

transmitted light. Agar: Streak culture: A thick, white, milky layer, covering the whole surface of the agar. The lower portion becomes somewhat wrinkled..

Plate culture: Surface colonies: Shiny, almost porcelain white in color, when about 1-32 inch in diameter often send out little branches of processes on one side, giving a very characteristic appearance. Submerged colonies: Small, spherical dots.

Bacillus C.

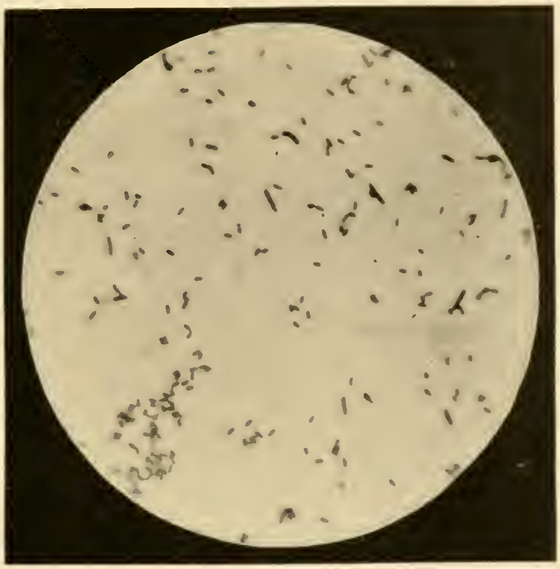
General characters: Shape and arrangement: Bacilli, with rounded ends, occurring in chains. Motility: The chains swim with slow, steady, undulating motion. Spore formation: Large, oval, centrally located spores. Relation to temperature: Develop rapidly at 37½ deg. C.; more slowly at 20 deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Liquefy readily. Gelatin: Stick culture: Growth throughout, but most abundant at surface. A trumpet-shaped, lique-

fied portion is quickly formed, with flocculent material in suspension and precipitate at bottom. Film on surface. Plate culture: Surface colonies: At first white and small. As soon as they break through the surface liquefaction commences, and colonies rapidly become large and of a homogeneous gray color. At end of a week colonies are 1 inch in diameter and covered by a thin film, with concentric markings and fluted edges. Submerged colonies: Rounded and white. Soon break surface of gelatin and begin to liquefy. Agar: Streak culture: Thick granular layer, with dull luster.

Edges sharply defined and scalloped. At the end of two or three days wrinkles appear on older portions. Plate culture: Surface colonies: Smooth and somewhat waxy in appearance. Often spread to form irregularly shaped patches with thickened edges. Submerged colonies: Small when separated, but often unite, forming a thin film on lower surface of the agar.

Bacillus D.

General character: Shape and arrangement: Bacilli, occurring singly and in chains. Motility: Chains not motile. Single cells move with slow serpentine motion.



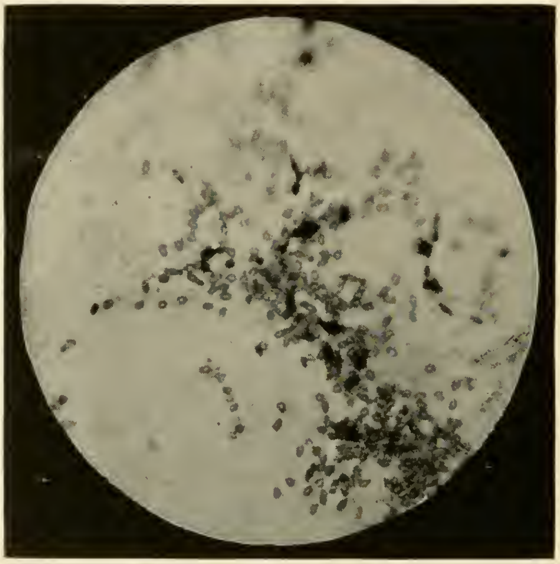
Bacillus U. Vegetative State From Agar.
Magnified 1,000 times.

Spore formation: Spores formed in center or near one end. Relation to temperature: Develops rapidly at 37½ deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Liquefy. Gelatin: Stick culture: Growth slight, but noticed throughout. Liquefaction soon begins. Plate culture: Surface colonies: First appear as white dots. Liquefaction begins quickly, and a liquefied saucer-shaped depression, with a white dot at center, is soon formed. Colonies rapidly become large, and have flocculent precipitate near center and finger-like processes projecting inward from edges. At end of a week the plate is nearly all liquefied and a thin film is developed at surface. Submerged colonies: Few and small. Agar: Streak culture: Thick, slimy growth readily removed. It occurs in form of scalloped patches, with smooth edges. Plate culture: Surface colonies: White or

gray, regular in outline, and smooth and shiny when young. Later become somewhat irregular in shape. Submerged colonies: First appear like woolly or burlike rounded masses, which soon break through surface and become shiny and smooth, like surface colonies.

Bacillus E.

General characters: Shape and arrangement: Long, narrow bacilli, generally occurring singly. Very variable in size. Motility: Move rapidly, with eccentric darting and twisting movements. Spore formation: Small, oval centrally located. Relation to temperature: Develops rapidly at 37½ deg. C.; slower at 20 deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Non-liquefying. Gelatin: Stick culture: Slight spreading growth at surface, and growth all along line of inoculation. Filmy, ragged surface. Growth at end of second day. Transparent. Plate culture: Surface colonies: circular; bluish by transmitted light. Grow to about 1-8 inch in diameter. Submerged colonies: Small white dots, developing



Bacillus U. Spores.
Magnified 1,000 times.

more slowly than surface colonies. Agar: Streak culture: In growth very similar to A. Bluish edges, finely dissected. Surface of Agar covered with a thin, white layer, finely wrinkled at the base. Plate culture: Surface colonies: At first small rounded masses, which on the third or fourth day show a thin surrounding outgrowth appearing bluish by transmitted light. Submerged colonies: Many small colonies about size of pin points.

Bacillus T.

General characters: Shape and arrangement: Rods occurring singly in short chains. Motility: Slightly motile. Spore formation: Oval spores, filling nearly the whole cell. Relation to temperature: Develops more rapidly at 37.5 deg. C. than at 20 deg. C. Relation to air: Aerobe and facultative anaerobe. Relation to gelatin: Liquefies. Gelatin: Stick culture: Development all along line of inoculation in

twenty-four hours. Liquefaction takes place, forming a trumpet-shaped mass, somewhat depressed at surface. A film develops on surface, and a flocculent substance is held in suspension . Plate culture: Surface first appear as small spots. Soon liquefaction begins, forming a cup-shaped depression, with a central, whitish mass. At end of a week a thick, waxy scum, marked by concentric rings, covers the entire surface. Agar: Streak culture: Thick, gray film, with irregular edges. Dull, granular mat surface on lower portion, and smooth and lustrous above. Plate culture: Surface colonies: Grayish or brownish in color, irregular in outline. Thickened edges; sometimes a dot is seen at center. Submerged colonies: Like surface colonies in general appearance.

Bacillus Y.

General characters: Shape and arrangement: Stout, thick rods, occurring singly and in chains. Motility: Slow, serpentine motion; chains also motile. Spore forma-

Plate Culture, Showing Colonies of Bacillus U.
Found in Cans of Sour Corn.

tion: Oval spores. Relation to temperature: Develops more rapidly at $37\frac{1}{2}$ deg. C. than at 20 deg. C. Relation to air: Aerobic and facultative anaerobic. Relation to gelatin: Liquefies rapidly. Gelatin: Stick culture: Growth throughout in one day, and liquefaction already begun at surface; much increased on second day, and flocculent precipitate in lower part of liquefied portion. Gelatin finally becomes entirely liquid, and have sediment formed. Plate culture: Surface colonies: Circular and rapidly liquefying; soon become covered with film. Saucer-shaped depression formed, at center of which is a flocculent, suspended mass, surrounded by ring of clear liquid. Submerged colonies: Small and inconspicuous. Agar: Streak culture: Very thick, much-wrinkled layer, white and somewhat shiny. Edges finely scalloped. Plate cul-

ture: Surface colonies first appear as small dots; later form irregular spreading growths of varying thickness. Submerged colonies: Thin, blue, irregular in outline.

Bacillus Z.

General characters: Shape and arrangement: Bacilli, occurring singly and in long chains. Motility: Moves with slow serpentine motion. Spore formation: Small, oval, centrally located spores. Relation to temperature: Develops rapidly at 37½ deg. C.; more slowly at 20 deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Liquefying.

Gelatin: Stick culture: Growth throughout and liquefaction at surface at end of first day. On second day liquefaction has spread to walls of tube, a wrinkled film was

Bacillus W.
Magnified 1,000 times.

present on surface, and flocculent precipitate in suspension. Plate culture: Surface colonies develop rapidly. When about 1-16 inch in diameter liquefaction begins. A central area of flocculent material is present. At end of a week colonies are large, and are covered by a thick film of waxy appearance and showing concentric rings. Submerged colonies: Small. Agar: Streak culture: A thick, white layer, of rather dull luster and finely granular appearance, covers the whole surface of the Agar. Plate culture: Surface colonies: Irregular in outline, slightly thickened at the center. Brown and somewhat shiny. Some colonies show irregular outgrowths and appear

woolly. Submerged colonies: Spread on lower surface of Agar, forming a thin layer, which appear bluish by transmitted light.

Bacillus S.

General characters: Shape and arrangement: Bacilli, generally occurring singly, but frequently in chains of three or four.

Motility: Quick swimming motion; chains also motile. Spore formation: Small, oval, centrally located spores. Relation to temperature: Develops more rapidly at 37½ deg. C. than at 20 deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Liquefies rapidly. Gelatin: Stick culture: Growth throughout in twenty-four hours. Liquefaction at surface. Thick film, marked with concentric rings on surface. At end of a week liquefaction extends to walls and ¼ inch down from surface. Plate culture: Surface colonies at end of two days are small, and white or bluish in color. Liquefaction begins about the third day, and proceeds slowly

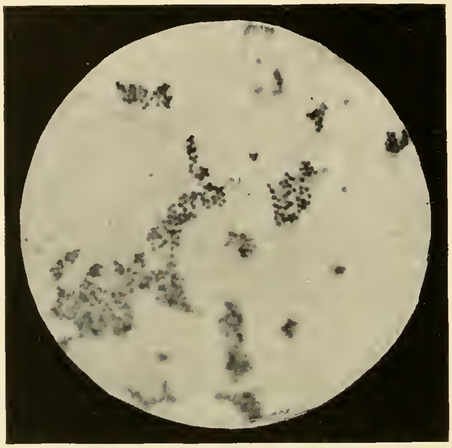
Plate Culture, Showing Colonies of Micrococcus X.
Found under husks of green corn.

until the whole plate is liquid. Colonies form saucer-shaped depressions with a central disk of gray and sharply defined edges. Submerged colonies: Small, irregular, and hazy in outline. Agar: Streak culture: A thin, smooth, shiny, transparent layer, with bluish color and scalloped edges, covering nearly the whole surface. Plate culture: Surface colonies first appear as small, round, white spots. Spreading soon begins, and stellate or branched colonies, with bluish fluorescence are formed. If many colonies are present on the plate the branching is less conspicuous, and the plate soon becomes covered with a thin layer.

Bacillus U.

General characters: Shape and arrangement: Rods occurring singly and in chains of two or three elements. Motility: Rapid, serpentine and spinning motion.

Spores formation: Oval spores formed. Relation to temperature: Develop rapidly at 37½ deg. C.; more slowly at 20 deg. C. Relation to air: Aerobe and facultative anaerobe. Relation to gelatin: Liquefy.



Micrococcus X. Taken From Above Colonies.
Magnified 1,000 times.

Plate Culture, Showing Colonies of Bacillus W at End of Forty-eight Hours
Found in cans of sour corn.

Gelatin: Stick culture: At end of first day faint growth along needle track. On second day slightly liquefied at surface. Liquefaction spreads rapidly to wall of tube, and whole upper portion soon becomes liquid. Plate culture: Surface colonies: When very small show slight branching, but as soon as liquefaction begins colonies become circular and form depressions in the gelatin. Plates become entirely liquid in a few days. Submerged colonies: Small, spherical and inconspicuous. Agar: Streak culture: Smooth, white, shiny layer, with branched or serrated edges, and extending over nearly the whole surface. Plate culture: Surface colonies: Circular when very young, but branching takes place as colonies develop, producing stellate forms. The fewer the colonies the more marked the branching.

Plate Culture, Showing Colonies of Bacillus W at End of Twenty-four Hours.
Found in cans of sour corn.

Bacillus W.

General character: Shape and arrangement: Stout rods, rounded ends, generally in chains. Motility: Swim rapidly with undulating motion. Spore formation: Oval spores centrally located. Relation to temperature: Develops rapidly at 37½ deg. C.; slowly at 20 deg. C. Relation to air: Aerobe and facultative anaerobe. Relation to gelatin: Liquefies rapidly. Gelatin: Stick culture: Development well marked at end of twenty-four hours. On second day a large trumpet-shaped mass of liquefied gelatin is formed, in which is suspended a heavy flocculent precipitate. Plate culture:

Surface colonies: Circular, rapidly growing, and containing a gray or brown precipitate at center, surrounded by a broad ring of clear liquefied gelatin. On long standing surface becomes covered with a thin, scaly film or incrustation. Submerged colonies: Small, circular or oval. Agar: Streak culture: A thick, fine granular layer, with bluish irregular and indistinct edges, covering nearly the whole surface of the Agar. Plate culture: Surface colonies: Granular, brownish-gray colonies, of rather dull luster, irregular in shape and thickened at the edges. Young colonies appear somewhat finely branched or woolly.

Micrococcus X.

General characters: Shape and arrangement: Micrococci, occurring singly and in irregular clusters. Motility: Not motile. Spore formation: Not observed. Rela-

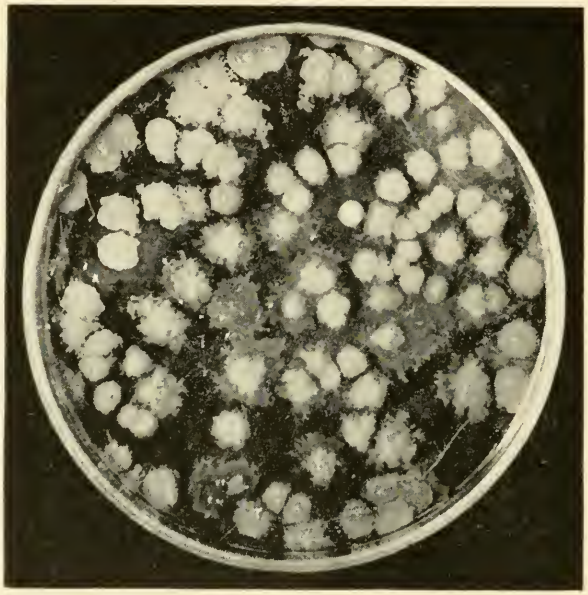


Plate Culture, Showing Colonies of Bacillus W at End of Twenty-four Hours. Found under husks of green corn.

tion to temperature: Develop well at 37½ deg. C.; slowly at 20 deg. C. Relation to air: Aerobic and facultatively anaerobic. Relation to gelatin: Does not liquefy. Gelatin: Stick culture: Development: Slow; growth throughout somewhat raised at surface, forming a small button-like mass. Plate culture: Surface colonies: Sharp outline, raised above surface concentric markings, bluish white in color, and of somewhat waxy luster. Submerged colonies: Small, spherical. Agar: Streak culture: Growth closely follows line of inoculation. Bluish white, semi-translucent, lustrous and moist. Plate culture: Surface colonies: Circular and somewhat dome-shaped. White in color. Develop in about three days. Submerged colonies: Small, oval or rounded.

CHAPTER III.

At the annual convention of the Atlantic States Packers' Association and the Western Packers' Canned Goods Association, held at Detroit in February, 1899, Professor Prescott and Mr. W. Lyman Underwood were again engaged to deliver papers covering their experiments, following their report of the previous year at Buffalo.

Professor Prescott was first introduced, and spoke as follows:

THE CAUSE AND PREVENTION OF SOUR CORN.

The question of preservation of food is at the present time one of the most interesting and important in the whole field of applied science, and we certainly regard ourselves as fortunate in being again asked to speak before an assembly of those who have so vital an interest in this subject. The events which have transpired since we had the pleasure of addressing the Buffalo Convention a year ago have only made more evident and more impressive the necessity for sure and safe processes of food preserving, and for more accurate knowledge regarding these processes of food preserving, and for more accurate knowledge regarding these processes.

So, in accepting your president's courteous invitation to speak on certain phases of the general subject, we feel that perhaps we can do no better service than to begin by briefly considering some of the facts that find application in all branches of the industry. All kinds of canned goods, so far as we are aware, are liable to undergo fermentative or putrefactive changes unless some means are taken to guard against such action. I would like, first, to speak of the causes which lead to these troubles. In the early days it was believed that the access of air was responsible, but as can be easily demonstrated by a simple experiment, this view was fallacious and we must seek further for the true cause of decomposition. The view at present held by intelligent and observing people is that these changes are brought about by the activity of very minute living things which we commonly and popularly speak of as germs, microbes, micro-organisms, or bacteria. All these terms are used somewhat indiscriminately, and all mean practically the same thing.

At the outset, I would like to caution you against a very widespread belief that all bacteria are disease-producing in their nature. As a matter of fact, the useful germs greatly outnumber the harmful ones, as the useful citizens of the community outnumber the criminals. Perhaps I cannot make the contrast more convincing than by stating that there are now on the market preparations of bacteria which are used in the ripening of cream, in the production of flavor in butter and for the increase of fertility in the soil. In fact, without the action of bacteria, we could not exist, so we must regard them as friends rather than foes, even though there are a few species which might do us injury. That the majority of them are harmless is evident from the fact that with every glass of water we drink we take in hundreds of them, and they are present in ordinary milk in great numbers. The upper layers of the soil abound in them. In fact it is difficult to find many places where they are not present.

From what I have said of their abundance, one may perhaps get an inkling as to their size. This may be best realized, I think, by some comparisons.

(Mr. Prescott here showed charts and models of several kinds of bacteria magnified 50,000 times.)

A yeast cell magnified 50,000 times would be about as large as a football; a man magnified in the same proportion would be about fifty-four miles high and his hand about three miles broad. We might regard a bacillus one twenty-thousandth of an inch in length as perhaps an average sized organism, while some of the largest ones might be one four-thousandth of an inch long.

The shape of these organisms may be classified as spherical like a ball, elongated like a lead pencil, or spiral like a corkscrew. These are the type forms and we get all gradations between them. Then, too, we find differences in the way in which they are arranged, sometimes being arranged singly, sometimes growing into long chains or threads and sometimes simply forming irregularly shaped groups or clusters.

We do not find these little plants complex in structure, made up of numerous organs, but rather they are very simple, being composed of a single cell. On account of the very small size, we are unable to state very definitely about the structure, except that they have a thin membraneous covering like a sausage, but as in the case of the sausage also, we do not know what may be inside.

By proper means we can cultivate the bacteria, and observe the changes which they bring about in various media, and it is by such cultures, as they are called, that we learn of the nature of each particular kind of bacteria, and the chemical reactions which it will induce. On certain kinds of media we get the appearance of circular or branching spots known as colonies, each colony developing from a single germ. It is only when collected in such large masses, containing thousands or millions of individuals, that they become visible to the naked eye; to observe the single germs requires the high power of a microscope. Often they are seen in lively motion. When actively growing, or as we say, in a vegetative condition,

the process of reproduction goes on with great rapidity, each germ dividing into two, these into four, and so on, thus in a few hours giving rise to vast numbers. Under favorable conditions this splitting of one germ into two may take place as often as once in twenty or thirty minutes, which at this rate would give rise to billions in the course of ten or twelve hours unless their own products of growth were sufficient to check the reproductive process. It is when in this vegetative state that the bacteria are most active, and bring about their decompositions with the greatest rapidity.

Perhaps of greater importance, from the point of view of the canner, are the more resistant forms known as spores, which are modifications of some of the rod shaped bacteria, enabling them to endure hard times or conditions unfavorable for development. When in this condition they can live for months apparently dead, but awaiting to develop again into actively vegetating forms as soon as the conditions become favorable. When in this condition also, the bacteria are much more difficultly killed by the action of heat, hence they are a continual source of trouble to the packer unless he is certain that his process is sufficient to kill them. While ordinary vegetating bacteria are readily killed at the temperature of boiling water, or even by comparatively short heating at temperatures below boiling, the spores will frequently withstand several hours of boiling. It is not uncommon to find spores which can be boiled for five hours and remain uninjured. Some forms can endure much more than this, and we have found some in our work that are not killed by boiling for eight hours continuously. It is then obvious that simply boiling for a short time does not offer a very sure means of processing. If no spores are present there may be no trouble, but owing to the abundance of the bacteria, we should always bear in mind that spores may be present and so formulate our process accordingly.

Although so impervious to the heat of boiling water, the spores are killed by increased heat, as for example, by steam under pressure; the more intense the heat the less time can the spore endure. This then is the true reason why retorts or kettles in which steam under pressure is used have so largely replaced the water baths. This will be treated more fully by Mr. Underwood.

I have already mentioned the rapidity with which bacteria develop. It is, however, only when conditions are favorable that we find this action going on with such marvelous speed. We may regard as favorable conditions warmth, moisture, and a plentiful food supply. The substances which serve as food for us are excellent food for the bacteria, so that when present in canned goods they are generally in a most favorable environment. There is a wide variation as to the temperature which will allow development, but in general, low temperatures exert a restraining influence, while at blood heat the activity is much increased. Since the germs take in their food by direct absorption through a cell membrane, moisture is essential to their well-being, and the preservation of food by drying depends upon this fact, as in a dried state the germs can get no food and so

are inactive. As soon as the amount of moisture becomes sufficient, however, they immediately begin to propagate.

But perhaps the most interesting facts about these germs are not regarding their size and shape, but deal rather with their abilities to act upon organic materials of manifold varieties, changing them into other substances lower in energy and sometimes of an entirely different nature from the original substances. So well-defined are some of these processes that we might almost regard bacteria as chemical reagents, which when added to a fermentable or putrescible material, give rise to definite compounds of various kinds. This action which is brought about only by the vegetating germs forms a part of the functions of the organism just as much as our own processes of digestion and absorption constitute a part of the work of our own bodies. The spores themselves being inactive must go through a process of germination as we say, in some respects similar to the germination of a seed, before they can carry on these changes. In this germinating process the tough, resistant outer coating of the spore is ruptured or entirely cast off, and an active vegetative cell emerges. This process of spore germination only takes place when the conditions become favorable for the growth of the normal or vegetable cells. This may account for some cases of spoiling which appear to be belated, or which, perhaps, do not appear until spring time, or until the cans are put into a warm place. Then the chemical changes and the multiplication of the bacteria go on side by side until perhaps the substances formed are present in such an amount as to prevent further development.

All these chemical changes brought about by the activity of the bacteria and other micro-organisms like yeast and moulds may be grouped together in a class to which we apply the fermentation. This term, although originally used to designate the change brought about by yeast in which a sugary liquid like a fruit juice is changed to an alcoholic one, is now used in a much broader sense, including the changes from cider and wine to vinegar, the souring of sweet milk, and the transformation of sugars into various acids, and the breaking down of various complex substances into simpler ones. It therefore includes the changes which are brought about when canned goods undergo deteriorations caused by bacteria.

These fermentative changes can be prevented in two ways. First, by sterilization by heat, by which we mean that all bacteria, whether in a spore state or vegetative state, are subject to such a temperature that they are killed outright and therefore rendered inert. This is the general principle underlying all canning operations, and is the only sure and safe one to follow. Or, we may prevent these putrefactive or fermentative changes in another way, that is, by the use of antiseptics. By an antiseptic, we mean a substance which does not necessarily kill the germs, but restrains or prevents their development. Growth may again take place, however, if the restraining influence is removed. The use of antiseptics has many disadvantages, and notwithstanding the fact that opinions as to their unwholesomeness vary, there seems to be no reasonable excuse for the use of an antiseptic in any food preparation. An objection which cannot be too

strongly presented is that substances which are injurious to bacteria are also in general likely to be injurious to the human organism. Moreover, the presence of even small amounts of preservatives frequently gives an unpleasant and unnatural taste to canned goods.

In some states, as, for example, in Massachusetts, the laws regarding adulterations in foods and the use of antiseptics are stringent and well-enforced, as it is the desire of the Commonwealth to protect the health of citizens in so far as possible. Had there been any national law of this kind, we should probably not now be undergoing the deplorable war investigation.

In my foregoing remarks I have tried to make clear the facts that fermentation or spoiling in can goods in general is brought about by bacterial action and that the bacteria may be in a vegetative state or a more resistant spore state, but that in either case they may be destroyed by proper heating. Aside from these general considerations, it is obvious that, on account of the very numerous and widely different varieties of canned foods, the more specific rules which apply in one case may not at all fit another case, but that each product must be treated separately.

Bearing this in mind, I wish now to consider more in detail the subject of the fermentation of sweet corn, or as it is better known to the packing trade, the production of sour corn. When this occurs a change is brought about by action of bacteria which were not killed in processing. These bacteria belong chiefly to the lactic acid group, that is, the general change is similar to that brought about in the souring of milk. In each case we have a sugar acted upon by the bacteria and split at once into an acid. In both cases lactic acid is the principal one formed. In addition to the lactic acid there are frequently produced in the corn small amounts of other acids, as acetic, formic and butyric and other products of fermentation. Gases, as carbon dioxide and hydrogen, may sometimes be produced in considerable amounts, particularly if the temperature be not too low, and in that case a "swell" is the result. At low temperatures gaseous products may be formed but at once dissolved in the liquid within the can, thus giving no swelling until the can is warmed so that the gas is driven out of solution. Or we have another variation of this fermentation taking place in which the amount of gas evolved is very small, but almost the whole energy of the bacteria is used in splitting the sugar into lactic acid. This would take place when food conditions are most favorable. This would give sour corn without swelling. This, however, is not the only case of spoiling without swelling, as the same thing occurs with many other products when the processing is insufficient, notably "black lobster," which has caused tremendous losses. These different modifications of the same fermentation are brought about by slight differences in the conditions, or perhaps by slight differences in the physiological activity of the germs. We may also note differences in a fermentation according as it proceeds with a plentiful supply of air, or without the access of free atmospheric oxygen. In the latter case, the oxygen necessary for the further multiplication and for the food of the organisms must be obtained by breaking down some of

the substances in the corn, and in this process gases are generally evolved. As there is no likelihood that merely a single species of germ is present, especially when the action is in its early stages, we get a most complicated set of fermentations taking place, in all of which the chief product is an acid. Later, one species of bacteria may develop at the expense of the others, and the acidity produced will probably increase as the temperature is increased.

The sugar most rapidly split up by the bacteria is glucose, and undoubtedly the sweetness of young corn is due for the most part to this compound. In older corn, it is changed to starches and a little cane sugar, but in the heat under pressure to which the corn is subjected, these starches and sugars are doubtless hydrolised, that is, they unite with water and form glucoses again. This process is not necessary, however, as the bacteria themselves can frequently bring about this change. Aside from the carbohydrate food there is no reason why fermentation should not take place if the germs are present as the water and nitrogenous substances necessary for the bacteria are present in abundance.

In addition to the recognition of this acid by taste or smell, it can be very easily demonstrated by chemical means, in fact, it might even be detected when in such small quantities that there is practically no sour taste.

(Mr. Prescott here showed by an experiment how the acid in corn could be detected.)

The possible sources from which the bacteria might get into the cans of corn may perhaps be briefly discussed. There are five principal sources from which infection might occur.

1. From the corn itself.
2. From handling, and utensils in use.
3. From the air.
4. From the water supply.
5. From the syrup or brine.

Regarding the first three of these sources I shall say nothing, as they will be mentioned in the second part of our paper. The question of water supply, while it should not be neglected, does not have as great significance here as in some other manufacturing processes. It is, of course. desirable to have a good water supply. The number of bacteria in water varies according as a well or surface supply is used and according to the amount of organic matter present. The bacteria present in normal water are generally very readily destroyed at a boiling temperature, and many of them are killed at lower temperatures. Any spore forming bacteria would be killed in the final process as very resistant water forms are rare. Therefore, we may dismiss the question of water supply as relatively unimportant in general, although it should be borne in mind that a water supply might become so infected as to be a menace to the packer.

As it has been suggested that the syrup or brine used in the corn might perhaps be a source of infection, we have made some very careful experiments, using the components in the same proportions as would be used

in actual canning operations on a large scale. We first took up the case of cane sugar. I went to a sugar refinery and obtained samples of various raw sugars and refined products. We first studied these bacteriologically, subjecting them to quantitative examination, and then making an investigation to find out if solutions of these sugars would support bacterial life. In the poorer grades of raw sugar we found bacteria to be present in considerable but not great numbers. Moulds are also quite numerous. The higher grade raw sugars, both cane and beet, contained few bacteria, and the refined product was practically free from germs.

The raw sugars, when dissolved in sterilized water and allowed to stand, showed a rapid increase in the number of bacteria, demonstrating that they would support bacterial life. In the refined sugar, on the other hand, there was apparently no increase, thus showing that in the process of refining the germs are destroyed.

Pure cane sugar is not generally regarded as a good food for bacteria, yet our results showed that when nitrogenous matter is present in small amounts a five per cent solution of cane sugar will support bacterial life.

Our next experiments were made with the brine of the same composition as that used for corn. Sterilized brine was inoculated with bacteria derived from sour corn, and put into an incubating chamber at the blood heat. Development occurred, but in only limited amount, and thus far we have obtained no evidence that bacteria will develop rapidly in brine, particularly as the salt present exerts a restraining influence. The result of our work, however, showed that slight development might occur, therefore, we must emphatically assert that brine should never be allowed to stand over night, and that the utensil holding the brine should be carefully washed out with boiling water each day. Unless these precautions are taken, there is the possibility that germs might develop during the night, form spores, and so infect the whole of the next day's pack. Of course, with proper processing these spores would be killed, but if the retorts were running close to the danger line this would be less likely to happen.

The brine used in the foregoing experiments was made with sugar as the sweetening substance. As saccharin is frequently used for this purpose, we have made some investigations as to its relation to bacterial development. Saccharin is a coal tar product containing carbon, hydrogen, nitrogen, oxygen and sulphur, and in the pure state has a strong acid reaction. Probably on this account the statement is made that it is antiseptic in its action, and hence better to use than cane sugar on this account. We first studied the antiseptic power of saccharin. A strong solution was made which was neutralized by the addition of sodium bicarbonate as is directed in the rules for use. This strong solution was used as a basis, and from it more dilute solutions were prepared. The strong solution contains about three per cent. saccharin by weight, and for the tests under consideration, it was used full strength and also diluted in the following proportion: 1 to 2, 1 to 4, 1 to 8, 1 to 10, 1 to 20, 1 to 50, and 1 to 100. To these solutions, in flasks, was added a small amount of

nutrient substance and a culture of bacteria. The bacteria used in these tests of antiseptic value were some of the germs originally found by us in sour corn, thus making the examination of particular interest.

If saccharin was strongly antiseptic we should expect to find no growth appearing in the flasks when it was present. We found, however, that such was not the case. All the flasks showed some growth, but in those containing the strong solution there was much less than in the weaker solutions. In the latter there was practically no restraining influence at all.

These results show conclusively that the antiseptic or preserving power of saccharin has been very much overestimated. As the weakest solution used in our experiments contained about three times as much saccharin as would be in syrup or brine it is evident that it has no preserving power when used in this way. Indeed there seems to be some ground for belief that it would increase the bacterial food contents of the corn. Our results would indicate that compared with cane sugar the latter has the greater preserving power as used in corn packing. Saccharin is, however, much sweeter, although to many the taste is objectionable.

It has been reported that the use of saccharin in any food product has been prohibited by law in Germany on the ground that it is injurious to health. In this country, however, it is not regarded as an adulterant, as sufficient evidence of any injurious nature is lacking, and its use in canning will doubtless remain a matter of individual taste among packers.

From what has been said regarding the effect of temperature on the development of bacteria, I think you can readily see why it is that some seasons are far worse for packers than others, and why some localities may suffer more severely than others even if they are not far distant. Thus, in a very hot summer, like last season, Maine would have a decided advantage over New York and the Central States, because of its more northern latitude, and consequently cooler climate. In a similar manner a wet or a dry season probably exerts an influence on the development of germs in nature, but as data on these points are necessarily hard to obtain we can do no more than call attention to them.

In this paper I have tried to express briefly, and I hope in a clear and straightforward way, what we regard as some of the important facts from the point of view of the canner. I hope I have shown the necessity for scrupulous care in every step of the whole canning process. In view of the many sources from which trouble may arise I believe the best results will not be obtained until some measures are taken to obtain accurate scientific information along these lines. I can see no reason why the knowledge of the fundamental principles should not be sought just as eagerly in the preservation of food as in any other branch of manufacturing. Surely none can be of greater importance to the public welfare. It is very easy to talk learnedly and at length about science in the abstract, but unless one can show just how this science has a practical bearing on the problems that are daily encountered in the industrial world, such talk is vain and may be wrongly construed.

The chair next introduced Mr. W. Lyman Underwood, who spoke on the subject:

THE CAUSE AND PREVENTION OF SOUR CORN.

Last year when I had the pleasure of addressing you at the Buffalo Convention I told how, in order to discover the cause of a mysterious loss which we were experiencing with one of our products, I became interested in the study of bacteriology as applied to our business—the canning of fish and meat.

This question being solved and a remedy for the deterioration having been applied with success, I naturally became interested in some of the fermentations occurring in other branches of the industry. Sour corn, being the most prominent, about two years ago, with Mr. Prescott, I began an investigation of this subject and we have been working on it ever since.

As there are many packers present who were not at Buffalo last year, we have thought it best to make our papers somewhat in the nature of a review, although there are many new facts which are brought to your attention. At the conclusion of our article, which was presented to you at that time, we summed up our work as follows:

1. That sour corn appears to be always the result of bacterial action and due to imperfect sterilization.

2. That in case of insufficient processing souring does not always result unless the cans are subjected to conditions favorable to the growth of the bacteria within.

3. That some of the bacteria which produce sour corn are found on the kernels and beneath the husks of the corn as it comes from the field.

4. That these bacteria found on the ears of corn correspond in all respects to those originally found by us in cans of sour corn.

5. That swelling may be caused by bacteria other than those which produce sour corn, but it is also a natural consequence and a further development of this process of souring, provided the cans be subjected to a favorable temperature.

6. That so far as we have been able to discover, the organisms present in sour corn are capable of producing serious commercial damage and an unpleasant taste but are otherwise harmless.

7. That a vacuum is not necessary for the preservation of canned food, but is a valuable factor in the detection of unsound cans.

8. That the use of bleaches or any antiseptic material is not to be recommended and is unnecessary if proper methods of sterilization be employed.

9. That the utmost cleanliness at every step is absolutely essential.

10. That intermittent sterilization is not practical on a commercial scale.

11. That the open water bath is insufficient as a means of sterilization.

12. That, with the present methods of retorting, it takes at least fifty-five minutes for the temperature which is indicated on the outside thermometer (say 250 degrees) to be registered at the center of a two pound can of corn previously heated in a cooker to 189 to 190 degrees F.

13. That heating for ten minutes with a temperature of 250 degrees F. through the whole contents of such a can of sweet corn appears to be sufficient to produce perfect sterilization.

Another year's experience has more than convinced us of the correctness of these assertions.

In treating this subject we assume that the corn is in a perfectly sweet condition when it goes into the retorts in the can, and in our experience at many factories, we have always found this to be the case. Two facts prove the correctness of our assumption. First, we have found living bacteria present in cans of sour corn, thus proving that the sterilization was insufficient. They have been found repeatedly and with corn derived from many factories in widely separated localities. Second, in a large number of cases, especially in its first stages, souring may be found only at the centre of the can. When sampling a pack of corn where trouble is suspected this fact is often noticed. The corn may be sweet at the top of the can, but on taking a sample from the centre, souring will be found. Should these cans stand at a favorable temperature for some time the infection will become general throughout the whole contents. This proves that the heat sufficient for complete sterilization has not penetrated to the central portion on account of the low conducting power of green corn. It is, of course, possible that corn may become sour before going into the cans or before it reaches the retort, but it would be only under conditions of gross carelessness that it could occur in practice. If the corn had been sour before it was processed, this condition would not have been at first confined to the centre of the cans, but would have been equally distributed in all parts, and no amount of sterilization or processing could sweeten it again.

As has already been stated warmth is particularly favorable for the growth of bacteria. The organisms which infest sour corn develop most rapidly in a temperature at or about blood heat. Upon this property of the bacteria depends the great and elaborate system of cold storage. A low temperature is not necessarily fatal to bacteria, but it prevents their growth and so arrests fermentations brought about by them.

As a striking illustration of this principle we may cite the following facts: A Maine packer made two shipments of corn from the same day's packing, one to Bangor, Maine, and one to St. Louis, Mo., while a third portion of the same lot remained in his storehouse. In the following summer he received notice that the corn which had been sent to St. Louis had turned sour, while no complaint was received from Bangor. On examining the lot remaining in the storehouse no trace of sour corn could be discovered. These results are absolutely to be relied upon as this par-

ticular day's pack was under suspicion and had been set aside and all shipments from it carefully recorded.

In seeking the sources from which the bacteria causing this trouble might have come we examined ears of fresh green corn and upon the kernels and beneath the husks we have found bacteria which correspond in all respects to those previously obtained from cans of sour corn.

There are many bacteria which can produce sour corn but we regard these as the particular ones most likely to give rise to the trouble.

After the Buffalo Convention last year the statement was made that it would not be possible to isolate bacteria from cans of corn on account of the many thousand germs which were floating about in the air, since these germs were bound to get upon anything taken from the cans. This being the case it was said we would not be sure that any bacteria had come from the corn. In fact, the germs which were found must have come from the air and not out of the cans at all.

We will tell you how we obtained these germs and you may use your own judgment as to whether or not we are right in our conclusions. Imagine a glass case some two and a half feet square with a door on one side which opens by sliding upwards. First the dust was entirely removed from the inside by washing with a cloth wet with a strong solution of corrosive sublimate. The cans to be tested were washed with the same solution, then placed inside the case, together with a Bunsen burner and an awl which were also sterilized. Now washing the hands with corrosive sublimate and lighting the Bunsen burner, we are ready to begin. The door of the case is raised sufficiently to allow the admission of our hands. The awl is heated red hot and the can to be punctured is held over the flame and the hot awl is pushed through the tin. Should there be any vacuum in the can the flame, which must be germ free, will be drawn in, but no living germs can go with it, even if there should be any inside the case. Now with the platinum needle brought through this small hole and placed in the tubes of sterile culture media. If the can contained bacteria some of them would probably be taken out with the material on the needle and they would then continue to grow in the culture tubes, from which, by the usual methods, pure cultures could be obtained. No bacteria were found in sound or good cans of corn when treated in this same way.

There may be two varieties of sour corn distinguished as "flat sours" and those which show springy ends or "swells." We regard the latter as a further development of the former, which has been brought about by favorable conditions of temperature. However, we do not wish to give the impression that sour corn will always swell. As has already been said by Mr. Prescott, there may be a fermentation in which only acid and almost no gas is produced. If, however, the temperature be high enough there is generally a smaller or larger amount of gas evolved. This fact is made use of in the tests for sour corn which we gave you in our paper last year.

The fermentations arising in sour corn are similar in their cause and results to those occurring when milk sours. In each case we have an

undesirable product, yet we cannot regard it as essentially dangerous to health. Many people even like sour milk as buttermilk, and in some countries it is used as a part of the daily diet. So far as we have been able to ascertain none of the germs which we have found are disease-producing.

As we told you in our paper last year the vacuum is not essential for the preservation of canned goods, but is necessary in a way as an acid in inspection for the detection of unsound cans. It may seem needless to dwell upon this statement, yet so firmly has this mistaken notion that a vacuum is necessary become rooted in the public mind that even at the present time many people regard it as truth. It is well known to bacteriologists that many germs can live and develop in a vacuum, the presence of air actually preventing their growth. We can readily show by experiment that a vacuum is not essential for the preservation of corn and other canned foods. It is not the air which is harmful but the germs which may be contained in it, as we can easily prove by sealing a package with some substance, which, while freely admitting air, acts as a filter, thereby preventing the entrance of bacteria.

(Mr. Underwood here showed flasks the openings of which were sealed with plugs of cotton. In them were shell fish, which though they had been processed over two years, were in an excellent state of preservation.)

During the past two years the demand for very white corn has decreased somewhat, for many dealers are already looking with suspicion upon it. The following incident will serve as a practical illustration of this statement: While in one of our large wholesale grocery houses quite recently, my attention was called to some corn which I knew had been processed according to our suggestions. I asked how this brand was selling and was told that it had the best sale of any line of canned goods in that house. They had heard nothing but praise of it though it was considerably darker in color than the corn which had been put out by the same packer three years ago.

Here was an article containing no bleacher and thoroughly processed, thus insured against souring, which had an excellent sale at a high price, giving satisfaction to packer, dealer and consumer, because of its superior natural flavor.

Our attention has been called to a circular issued by a well known canned goods manufacturer which also has a bearing on this subject. We quote an extract from it:

"Our corn contains the natural cooked color and flavor due to complete sterilization and absolutely healthful ingredients, and we hope our patrons and consumers will aid us in destroying the market for white bleached or underdone canned corn; that all suspicion of a deleterious foreign substance may be removed."

We have here two views of this subject, that of the producer and that of the consumer, both in close accord, and were they accepted by all it is our opinion that sour corn would soon be a thing of the past. It is the fear that his product will be made unsalable that deters the packer from

processing his corn to the extent required for complete sterilization. Heat and heat alone should be the agency employed as a preservative for all canned food and the use of antiseptics, whether for bleaching or for any other purpose, should be condemned.

Too much attention cannot be paid to the question of cleanliness since it reduces the danger of infection. Dust and dirt are the vehicles by which bacteria are often carried, and it is essential that such conditions should not exist. The liberal use of water and steam will do much to remove the chances of trouble from these causes. A frequent source of infection and danger is found in the piles of corn cobs which are sometimes allowed to accumulate near the factory. Here fermentation sets in and in a short time multitudes of bacteria may be produced, which, upon drying, are easily carried by currents of air into the buildings. It is also important that the utmost despatch be exercised in handling the corn before it reaches the process room, that the liability of infection may be reduced to a minimum.

There are three methods of sterilization by heat which may be applied:

1. By steam under pressure in retorts.

2. By continuous boiling as in an open water bath.

3. By intermittent or discontinuous boiling.

As the last method is much in use in laboratories for sterilization of small amounts of materials, and is sometimes suggested as being practical on a larger scale, we wish to outline the principle and the process involved. Mr. Prescott has already told you that bacteria, when in the spore state, are very resistant to heat and that they do not always remain in this state of development. This fact is taken advantage of in the process of intermittent sterilization. Assume that a substance to be processed contains numerous bacteria, both in the spore state and in the vegetating condition. The substance is heated for a short time, perhaps thirty to sixty minutes, at a boiling temperature, 212° F. In the first cooking all vegetative organisms are killed, while the spores remain unharmed. The goods are now set away until the next day when the process is repeated. In the meantime some of the spores will have developed into vegetative forms, owing to the favorable food conditions. These are destroyed by the second heating. After the second heating the substance is again set aside for another day to allow the development of the remaining spores, and is then given a third and final heating, which, according to the old ideas, should produce complete sterilization. It will readily be seen that the use of this method involves the handling of goods a number of times, and moreover, requires a much greater outlay in plant and labor. Aside from the impracticability of adopting this method on a large scale, there are a number of other serious objections to its use, particularly with a substance like corn, which, as we shall presently show, is a poor conductor of heat. It may be sufficient to say at this time that in order to make the process at all efficient each heating would necessitate more than an hour's time. We have proved that it takes an hour and forty-five minutes for

a temperature of 212° F. to reach the centre of a can of corn. Moreover, there can be no absolute certainty that all spores of bacteria would develop into vegetative forms by the time of the third heating, and unless this were so the whole process would fail of its end.

In preserving nearly all the more putrescible foods, the open water bath has been almost entirely given up as an agency of sterilization. Practical experience has demonstrated that it is unreliable. Within the past year we have been in communication with a packer who had up to 1898 always processed his corn at boiling temperature. He frankly told us that they had had more or less sour corn each year and were very much puzzled by it. When one bears in mind that the spores of bacteria will often withstand eight to ten hours of boiling, the reason for this loss is not difficult to see; and it also offers a striking example of the insufficiency of this method. On the other hand, the use of steam under pressure, by which temperatures high above the boiling point of water may be reached, undoubtedly offers the best means of processing corn. So far as we can ascertain this is a safe and sure method if properly controlled. To obtain satisfactory results, however, it is necessary to know definitely the time which is required for the heat to penetrate to all parts of the can at whatever temperature it is the custom of the packer to give.

In order to determine more thoroughly the relations of time and temperature which should govern the sterilization or processing of corn, we have carried on during the past season a prolonged investigation of this subject involving over 400 tests, made both in wet and dry retorts, and in a number of different localities. The corn which was used in these experiments was of a consistency of the standard New York quality which had been run through the cooker at about 185° F. This corn was processed at the following temperatures: 235, 240, 245 and 250° F. and at each of these temperatures different periods of 40, 45, 50, 55, 60, 65, 70 and 75 minutes were given. The method of procedure was as follows: In the centre of each can was placed a thermometer which registered maximum temperature reached. The cans were distributed in different portions of the retort and each test was repeated several times in order to get a larger number of readings from which to obtain our average results and to diminish any liability of error. The time was first taken when the outside thermometer showed the temperature at which the run was to be made, and at the end of the period of heating the cans were immediately cooled in cold water. The thermometer readings were then taken and the averages ascertained. As these may be of interest to you, we will give them in detail:

Minutes.	235°	240°	245°	250°
40	226	233	234	237
45	227.5	234.5	236.5	240.5
50	229	236	239	244
55	231	237.4	241	247.5
60	233	239	243	250

Minutes.	235°	240°	245°	250°
65	235	240	245	250
70	235	240	245	250
75	235	240	245	250

For comparison we have tabulated these results in the manner shown above. The figures in the first column indicate the duration of heating in minutes. At the head of the other columns are given the temperatures at which the tests were made while the figures below give the temperatures obtained for the different periods of time. In this way we can easily show the length of time required for heat to penetrate to the centre of the cans at any given temperature. It will also be noticed that the higher the temperature of the run the more quickly the heat reaches the centre of the can.

The results of these tests should not be applied universally, as the conditions may vary somewhat between individual packers or different localities. The conditions here referred to apply particularly to the consistency of the contents of the can, whether it be a very moist or a very dry pack. The amount of starch in the corn would influence the temperature somewhat; that which contained the more starch would take the longer to heat as would also be the case with corn which had but little moisture added as brine or syrup.

Our opinion has often been asked as to the advantages of the wet over the dry retort or vice versa, and we will give the facts as far as we have been able to obtain them from this line of investigation.

We in New England hardly know what a wet retort is and I myself have never seen one in use there, about all the processing being done with dry steam. It is a common thing to hear a packer say, "If water should stand in our retort it would spoil the cook and the goods would not keep." In a way he may be right, though the trouble would not be due directly to the presence of water. In running a dry retort it is very important to have a free exhaust to insure perfect circulation of steam and an even heat. Without it the circulation would be very imperfect and the temperature in some parts of the kettles might be lower than that indicated by the outside thermometer. With such conditions we shall find water in the retorts which has condensed from the steam and its presence is a direct indication that the heat might not have been equal in all parts of the retort. It is also important that a good exhaust be given in running a water retort as the rules of circulation and distribution of heat are similar in both cases. Our experiments with both methods have been made with retorts which were run correctly but in the usual way. Under these conditions we have found no advantage to be gained by the use of one kind rather than the other, unless it be a question of convenience, or work in handling. In both cases an equal time is required for a given temperature to be registered evenly in all portions of the retort, and no preference can be shown. The figures which we have given relating to heat and

time were derived from both methods and can be applied to one or the other.

As before stated, these tests cover all portions of the retort and from them we gain some knowledge of what has been considered rather a perplexing question, namely: Does it take longer for a given temperature to reach the central cans in a full retort than it does those at the top, bottom or sides, and is the heat at all times equally distributed? Our tests have shown that at periods between 30 and 60 minutes at temperatures from 235 to 250° F. the central cans are heated as quickly as any other, and the heat is evenly distributed throughout the retort. A very slight difference was noticed in short runs between the central and outside cans, but it was so small as to be of no practical disadvantage.

We have often heard it stated that the wet retort gives a better quality of "cook" than does the other method. It is claimed by many that the dry retort has a tendency to over-cook. This certainly has never been proved to our satisfaction, and we think a little deliberation on the subject will show that it is not a fact. Two kettles of corn were processed for 65 minues at 250° F., one was filled with water and the other was run with dry steam. They were so timed that the cans from each were withdrawn and cooled together. After cooling six cans were opened from each lot and no difference could be noticed in texture or in color. We have made similar tests with other goods besides corn, and with the corresponding results. At first thought it would seem that the water retort must give a different quality of cooking, but it must be remembered that in each case the temperature was exactly the same and the cans being hermetically sealed the contents could not be affected by the water. The difference between processing with dry and wet retorts should not be confounded with ordinary roasting and boiling.

We may roast a piece of beef or we may boil it. Here there is a vast difference in the condition or texture of the meat so treated. But there is also a great difference between the methods of cooking. One is a very dry heat at a very high temperature; the other a moist heat at a comparatively low temperature. In both cases this heat comes in direct contact with the food, in the first instance driving the moisture from, and in the second adding moisture to the meat; while in the retorting of canned food, moisture can be neither taken from nor added to the substance in the cans.

Every packer should know to his own satisfaction just how long it takes the temperature at which he is processing to reach the centre of the cans of corn which he himself is packing. Never mind what your neighbor is doing. He may be packing corn that never sours and is giving it but 55 minutes at a temperature of 245° F. while your corn is sour which was given 65 minutes, 10 minutes more than he gave, at the same or perhaps even a higher temperature. But he forgot to tell you, or perhaps he did not know, that he was adding a much larger quantity of water than you were. To show what an important factor the amount of water is, I may state, that a registering thermometer, placed in a can of cold water, will show the same degree of heat that is indicated on the outside retort

thermometer, say 240° F., in six minutes, while it takes about 65 minutes for a registering thermometer in a can of hot corn of standard quality to show the same temperature.

Some packer may tell you that the limit of heat is reached in his pack of corn in 30 minutes. He knows this is a fact because he has used registering thermometers, but should you investigate his methods, you would likely find that his thermometers were not placed in the centre of the cans. They may have been placed in the centre of the cans, but no precautions taken to keep them there, so that the heat recorded was from the side of the can not from the most important point, the centre.

Experiments are of little use and may be often misleading unless they are carried out with a thorough knowledge of the principles involved. Sooner or later the rule of thumb methods must give way to the application of scientific laws, and there is no industry in which their application has larger scope than in that in which we are all engaged, the preservation or canning of food.

There were a great many questions asked of the professors and they replied to all with the best of their knowledge and ability. Among some of the questions propounded to them the following are taken:

Mr. Holden of Chicago asked whether or not the bacteria existed on the inside of the kernel of corn or always on the surface; and how about tomatoes for instance.

Answer—From what we found they are on the outside. Relative to the question of the liquid or brine, the professors stated that it would take 40 gals. of water, 16 lbs. of cane sugar, 8 lbs. of salt; or according to desire put in a little more sugar. That is about the proportions to make brine or the liquid. Which is the best climate to keep canned goods fresh? Dry, of course. The professors stated that in order to keep the goods healthy and fresh, cleanliness was necessary around the factory, for instance keep the corn cobs away, as if they are on a pile around the factory they will ferment and the unhealthy germ will be prevalent in the factory before and after the goods are placed in the can. In regard to the climate—I know of a case where a packer shipped corn to Bangor, Me., and from the same pack also shipped to St. Louis. The goods shipped to St. Louis they received complaints on, but none from Bangor. These goods were taken from a stock of goods where there was liability of bacterial action.

Mr. Simms—Are the bacteria which create what is known as cornstalk disease of the same class as those which are in the can? I ask this for the reason that I received quite a heavy loss through the death of cattle who had eaten corn stalks which were supposed to have been affected by this disease?

Answer—I do not think so, as I have eaten sour corn in the course of my experience and am still somewhat alive, although I may be tougher than your steers.

Mr. Polk—Does the quickness or the slowness in the cooling of the goods after coming from the process have any material effect on the color of the corn?

Answer—If it is thoroughly processed to cool at once is of advantage.

Mr. Ott—What temperature is the most advantageous and safest in processing corn? 250 appears to be sufficient to produce perfect sterilizing —65 minutes.

CHAPTER IV.

At the annual convention of the Canners' associations held at Detroit February, 1900, Messrs. Prescott and Underwood were not present, but a characteristic letter from them to President R. Tynes Smith, of the Atlantic States Packers' Association, was read, and, being pertinent in every way, it has been deemed worthy a place in this work:

Boston, Mass., February 7, 1900.

Mr. R. Tynes Smith, Baltimore, Md.

Dear Sir: For the past two years we have derived much pleasure from attending the conventions of the packers' associations held at Buffalo and Detroit, respectively, and we regret exceedingly that it will be impossible for us to be with you again this year.

At Detroit last year we listened with a great deal of interest to the experience of packers who had availed themselves of our suggestions, and conducted their processes in accordance with the methods outlined by us at Buffalo in 1898. It is a source of much satisfaction to find that the canners are, in general, manifesting so much interest in this subject, particularly so when it is remembered how reluctant many were at first to entertain any belief that bacteria could be at all responsible for many of the losses incurred in the industry. So firmly did the public mind connect bacteria with human disease only that it was natural, perhaps, that there should be some hesitation in accepting any theories which had to do with germs, and it is not to be wondered at that even now there are some who are still skeptical, or who do not fully understand the true relations which micro-organisms bear to spoiling and deterioration.

In looking over a recent issue of a paper published in the interests of the canned goods trade our attention was attracted to a statement in connection with the new form of contract for the sale of canned goods which has been drawn up by the New York Wholesale Grocers' Association. It is relative to "latent defects" which sometimes appear in canned goods, and it practically stated that all canned foods not only are liable to develop swells if they are much moved about or disturbed, but will invariably do so, the trouble being produced by some "latent power" within the can.

Without going into any discussion of the propriety of this clause as applied to the contract, we should like to consider this statement somewhat

in detail, for it furnishes food for a good deal of thought. If it is true, it is a virtual acknowledgment that no canned goods are perfectly sterilized or processed.

It is known by actual experience that this is not the case, and any packer who can not guarantee his goods unless they can stand quietly on the shelves should go out of business. To show at once the absurdity and fallacy of such a statement, it need only be cited that there are annually thousands of cases of canned goods transported on long sea voyages, which must of necessity receive severe and continued agitation, and that they do not always necessarily develop swells goes without saying. The disturbance and shaking up received in this way are far greater than could ever be obtained by any moving about in a grocery store, and one would expect the "latent power," if any existed, to be developed in a correspondingly greater degree. The facts, however, do not bear out this theory.

It is true that unless the canner knows absolutely that his process is right he is liable to have goods with latent defects, which are due to the presence of bacteria or other spores which have not been killed, and whose development may oftentimes be hastened by agitation and may result in swells. It can not be denied that under these conditions a latent power exists in the cans, which, if given the right conditions, will manifest itself in swells or other deteriorations, as we have shown in previous papers.

However, we not only question, but absolutely deny that swells may invariably be produced by shaking the cans, and any packer who admits that the statement referred to is true in his case at the same time acknowledges that his goods are not thoroughly processed, or at least that he does not know whether they are or not.

In other words, if a packer is sure that his product is put upon the market in a thoroughly prepared condition, there seems to be no reason for him to fear any swelling of his goods due to latent defects. It makes no difference whether the substance be corn or peas or any other food product, the principle underlying the preservation for indefinite periods is sterilization, and thoroughly sterilized foods should keep for years, as well as for months or weeks, so long as no mechanical injury is done to the cans containing them whereby bacteria could come in contact with the contents of the package.

There is one contingency which may arise which might seemingly disprove this statement. Sometimes conditions may exist where a very small percentage of loss is noticed in goods that have been thoroughly and sufficiently processed, this loss not occurring until a considerable length of time had elapsed after the goods had been put upon the market. Anyone who is well versed in cause and effect can readily account for this situation. In overhauling and inspecting a stack of canned goods previous to labeling and shipment there are often a few leaks which can not be detected, owing to the fact that the minute hole had been mechanically closed during the process of cooking by some particle of the substance within in such a way as to seal the opening effectually for the time being, thereby causing the

can to have a vacuum, and giving it all the appearances of a perfect can. By violent shaking at some later time such a particle may be dislodged, and the vacuum will be sufficient to draw in some germs with the air, and as a result of the bacterial action swelling would most probably ensue, though this could not, of course, be regarded as due to any latent power originally existing within the can.

Each year, as the knowledge of bacteriology advances, its application to the food industries becomes wider and of more importance. It has been shown that it is not the exclusion of air which causes canned goods to keep, but rather the exclusion of living germs. Year by year canners will find increasing necessity for the application of scientific principles in their business. As competition grows the need of accurate processes will become more and more apparent, and these processes will be worked out through the medium of scientific investigation.

A subject which can not be too strongly brought before the minds of practical men engaged in canning industries is the necessity of watchfulness as to the sanitary condition of the products which they put upon the market, and the more the public is made aware of the fact that the business is conducted upon sound and scientific principles the greater will be the demand for this class of foods.

Trusting that the convention of 1900 will be very successful, we beg to remain, very truly yours,

SAMUEL C. PRESCOTT,
WM. LYMAN UNDERWOOD.

CHAPTER V.

At Rochester in February, 1901, during the sessions of the various canners' associations present, Mr. W. Lyman Underwood read a paper covering the various bacteria found in canned goods, while Professor Prescott gave his attention to the subject of "Sour Peas." Mr. Underwood spoke first on

BACTERIA IN CANNED FOOD.

About five years ago Mr. Prescott and I published the results of some of our investigations, to find the cause of deterioration and loss that was being met with in certain canned foods, particularly fish products.

As the changes which such substances underwent were similar to fermentations or putrefactions, we came to the conclusion that, owing to insufficient processing or sterilization these peculiar conditions were caused by germs. In cans that had spoiled we found living bacteria, which, on being inoculated into good cans, produced the same striking characteristics that we had noticed in the original cans. We also found that a temperature of 212 degrees Fahrenheit, or a boiling heat, was insufficient to process these foods thoroughly, when certain germs were present. If these organisms were present it seemed to make no difference whether the goods were boiled for three hours or for eight hours. Over 90 per cent. of cans so treated spoiled when subjected to a tropical heat.

These experiments were carried on at the biological laboratory of the Massachusetts Institute of Technology and the report upon them was probably the first information that had been published upon work of this kind.

At that time the knowledge that the general public entertained in regard to bacteria was rather vague. Most people associated them only with disease. I well remember, when first we ventured to speak with some of the packers, on this subject, how we were met with a look of suspicion and in some cases were told that if we dared to connect germs with canned goods (a topic which was never to be discussed in public) it would ruin the business. So firmly was this idea rooted in the minds of many that, in our early work, we had to be extremely guarded about whatever we said upon the subject, lest we should not only offend people, but really so frighten them that they would not ever wish to eat any more canned food.

Our first paper was read in Boston, before the Society of Arts, an association for the advancement of science. A year after our publication the Canadian government issued the result of an investigation, which had been carried on under their direction, to ascertain the cause of "black lobster," as it was known to the trade, a trouble which seemed likely to demoralize the whole lobster-packing industry.

This deterioration was seemingly a very mysterious one, for the lobster meats turned dark without swelling the cans and, in some cases, the entire contents were changed into a black, foul-smelling liquid, without any indication that anything was wrong.

This investigation of the Canadian government confirmed the conclusion which we had drawn, namely, that the trouble was brought about through the action of certain bacteria that had the power to resist the boiling heat as ordinarily applied. As a method of prevention they recommended that canned lobsters be processed as follows: First, boil for one hour; then cool at once and keep cool from twelve to fifteen hours. Second, boil again for fifty minutes; cool and keep cool, as before, from twelve to fifteen hours. Third, apply same heat again. This time for forty minutes; cool at once. In warm weather give a fourth boiling of thirty minutes, after keeping goods cool for twelve hours.

By this system it will be seen that in warm weather four days would be occupied in finishing any one day's pack of raw material, and starting at the beginning of the season, after the third day, one would have to process daily the work of three preceding days.

While this method (which is known as intermittent or fractional sterilization) may be practical for the laboratory or in domestic and household work, it cannot be carried out on a large commercial scale, where thousands of packages have to be handled and processed daily.

The Canadian government report further states that if a temperature over 212 degrees Fahrenheit, the boiling point, were adopted it would necessitate the use of retorts, which few factories possess and which are beyond the reach of many worthy men. Later, it claims that the methods of using the retorts are faulty "because the temperature of 248 degrees Fahrenheit, which is commonly used, is too high for any tissue intended for food." That this statement is at variance with actual facts goes without saying, for nearly all our food, which is baked at home in an oven, is subjected to a much greater heat than that above mentioned.

Hundreds of retorts are being used to-day at temperatures ranging from 240 to 250 degrees Fahrenheit, and notwithstanding what the Canadian government has said we have found it possible to so sterilize canned lobster in retorts that it will keep perfectly sweet and hold its delicate flavor and color without danger of spoiling.

For a long time it has been known that canned lobster from one district was more apt to turn black than that from another. For instance, shell fish from the southerly shores of Prince Edward's Island are more liable to

develop this trouble when packed, than those from the Nova Scotia or Newfoundland coasts. There now seems to be a very definite explanation of this. The waters about Prince Edward's Island are shoal and the bottoms are, for the most part, muddy. In this mud (which is so rich that it is often used for fertilizing the land) bacteria abound, and it is easy to see that fish which have been feeding off such shores would naturally take in with their food many of these germs. Moreover, it is a well recognized fact that this blackening of canned lobster generally starts first in the meat of the tail, along the intestinal tract, where it would be expected to be found if the trouble were due to such germs.

On the other hand, the shores of Nova Scotia and Newfoundland are bold and rocky and the water is colder and deeper. Such conditions are unfavorable for the growth of bacteria, consequently the lobsters which frequent these territories are not liable to spoil, after being canned, because their food does not, to any appreciable extent, contain any of these germs.

In packing clams and oysters a peculiar kind of spoiling has sometimes been met with, which is similar in all respects to that occurring in lobsters. In the mud flats, where the clams are dug, we have found bacteria that seem identical with those found in the spoiled cans. As these microbes are prevalent in such localities it is very important that any fish which have frequented or have fed on such grounds and are to be used for canning, should be thoroughly sterilized or trouble may ensue.

As there are certain bacteria which affect fish and meat products so, also, there are others which may afflict the packers of fruit and vegetables, through their action on these foods. Sweet corn offers a striking example of this. You all know that thousands of dollars have been lost in the past through corn souring in the cans. Sour corn has probably been the greatest source of financial loss in the long list of troubles caused by these minute foes, and has been a veritable curse to the industry.

The result of our investigation in this direction we gave to you at Buffalo three years ago, and we hope that it has been of benefit to those engaged in this business. So far as we have been able to learn, there have been no further losses among manufacturers who have carried out our suggestions and we hope that sour corn is a thing of the past with them.

PEAS AND OTHER VEGETABLES.

There are, however, other vegetables which are subject to extraordinary changes. If not thoroughly processed asparagus will sour as will also squash, pumpkin and peas. In all of these products we have found bacteria which are very resistant to heat and which to eliminate require special treatment in each case. Perhaps the most extensive trouble that is now menacing the business is to be found in canned peas, and Mr. Prescott will soon tell you something of our experiments in this direction.

We often hear it said that years ago there never used to be any mysterious losses in the business, and we frequently asked why should there be more trouble now than then? We answer that formerly there were, no

doubt, as many, if not more, difficulties to be overcome than there are now, in proportion to the amount of business done. From a letter written by my grandfather in 1850 I quote the following: "The season, ending last year, has been a very strange one, and some of our hermetically sealed goods have spoiled, although they were put up with great care and of the best quality, and we can only suspect that the whole atmosphere has been impregnated with cholera that acted upon animal matter as it did upon vegetable. Our process has been the same for a number of years, with the exception of a little more care in that process last year than heretofore, because we had known of others having the same trouble. We wish you to be very particular and not suffer any of our hermetically sealed goods to go out of your hands until you have opened a few packages of each case."

It would seem by this that the year of 1850 was a bad one for those in the canning business. Bacteria were prevalent; but, in those days when there was no way of applying a sufficient heat for sterilization and it was not understood that a higher temperature was necessary, the packers probably suffered more losses in proportion than at present.

Why it is that some years are more disastrous in these respects than others is not definitely known, except in so far as climatic influences are concerned. During seasons of extreme heat and moisture the conditions are favorable for the growth of the micro-organism that causes these losses and at such times unusual care must be exercised to guard against them.

In the case of germs that cause disease it is not understood why they should be more prevalent in some years than in others; but that they are so is recognized and on such occasions every precaution must be exercised to retard their progress. I believe that it is for the interest of all packers to let the people know that their food is being prepared scientifically. For when this information becomes general then some of the prejudices against canned goods which are still deeply fixed in the minds of many will be removed.

Few people realize to what an enormous extent this industry has already grown. Some idea may be had of its proportions when it is known that if all the cans of tomatoes which were packed in 1899 were placed end for end they would reach more than half way round the world, for they would form an unbroken line of 13,428 miles of cans, and this is only one of the many varieties of foods which are preserved.

The science of bacteriology is advancing very fast and the importance of this study to the industrial world is becoming more and more evident each year. In Germany the government has appointed special commissions to work out some of the problems that perplex the preservers of food.

In our country the people are rapidly acquainting themselves with the ways in which bacteria work for the good or ill of all, and we are no longer obliged to speak in whispers when we discuss the germs that affect the canned goods business. We have always had to contend with them and always shall have to, for that is what the preservation of food means—a

war against bacteria, and while formerly it was a fight in the dark and against an unknown foe, now, with the modern weapons of the twentieth century and the knowledge of micro-organisms which science has brought to us, the lines of attack have become more clearly marked, but the struggle must go on as unremittingly as ever.

Mr. Chairman: I would like to ask Professor Underwood if he has done any further work on the subject of sour corn since the last paper was read.

Mr. Underwood: No, we have not nor have we arrived at any different conclusions than we did at that time; the times which we gave you and the heats which we thought necessary, we still think apply to that branch of the industry, and we have not heard, as I said before, that anyone has suffered any further loss who ran along the lines we suggested. If there have been any we should like very much to know it.

Chairman Hubbard: I have the pleasure now of introducing to you Professor Prescott.

SOURING OF PEAS.

Investigation of the souring of peas, by Prescott and Underwood. Read by S. C. Prescott:

When we addressed the convention at Detroit in 1899 we attempted to give a clear and concise account of our work in which we proved the time necessary for bringing about sterilization in canned corn. Although more than three years have passed since this work was done, we have as yet to learn of a case in which the methods we were able to arrive at have proved unsatisfactory, if applied properly. In describing this work it was our purpose to show not only how best the public could be served in this matter, but, also, how best the canner could be ensured against loss at the same time.

While the subject for consideration, viz., the bacteriological investigation of canned goods, has lost something of its original freshness owing to the fact that the ground has been gone over more or less thoroughly each year for the past three years, we are going to risk boring you, and give you a brief account of some work, conducted on a rather large scale, made to determine the cause and if possible to suggest a remedy for sour peas. The general plan of the work was much like that employed in the earlier investigation of sour corn; that is, we went to the factories in the packing season and studied the subject on the ground—packing peas under varying conditions, processing in various ways and making comparative experiments at different localities and different factories.

The cardinal points which we tried to ascertain were four in number:

1. Time necessary for sterilization.
2. Effect of "sweating" before processing.
3. Influence of age of peas on keeping qualities.
4. Effect of locality.

It is probably unnecessary, yet may not be out of place to state that we were convinced at the outset that sour peas were due to a fermentation caused by bacteria, which might not have been killed in processing, or which had already produced the souring before processing had been given. In many instances the former proved to be the case, for by making bacteriological examination in the way which we described for sour corn we were able to isolate and cultivate the organisms which were responsible was proved by the introduction of the germs obtained into perfectly sound cans, and thereby producing the spoiled condition. In this way we could spoil peas at will.

Being thus assured of our enemy, we proceeded to work out the four important points which I have already mentioned.

1. *Time Necessary for Sterilization.*

Sterilization is rendering free from bacterial life. The time necessary for sterilization may be defined as the shortest time in which goods may be processed with the result that they will keep indefinitely and all micro-organisms be destroyed. Experiment and experience both show that under certain conditions some peas will keep while others given the same treatment will not. Obviously, then, we can not regard this as proper sterilization, since unless all bacterial life is destroyed there still remains a grave danger of loss. On the other hand, if the most resistant germs are destroyed then we may be confident that the weaker ones will succumb.

In determining the time necessary for complete sterilization, we commenced with cans packed in the usual way, but which had been given a very short processing, and noted the effect of gradually increasing the length of the heating up to a period somewhat longer than that actually given in practice. This was repeated several times with peas of various sizes and ages, as will be seen later. These cans were incubated for a period of several weeks, and finally were all examined chemically for acidity, and were tested by taste. The chemical changes involved here may be two in number: first, and most marked, being the development of lactic acid and other acids by the action of bacteria upon the carbohydrates and, second, the formation of products having disagreeable taste and smell by the breaking down of the nitrogenous substances present in the peas. This result is also due to bacterial action.

Bacteriological examinations were also made to determine if germs were still present in the living state. Even in case the bacteriological examination gave negative results in the presence of strong acid, it does not show that bacteria have not been present and active. On the contrary, it shows that their activity has been great, but that the non-removal of their products has brought about a slow poisoning action which finally resulted in death. A few moments' consideration will show that in all living things such a rule is good. The substances which we throw off as a result of our life-processes may be poisonous in large amounts.

It was found by making thermometer experiments that it required a little less than ten minutes for a temperature of 236 degrees F. to penetrate to the center of the two pound cans. Of the cans that were run for fifteen minutes, 50 per cent. showed bacterial growth; of those run twenty minutes, 25 per cent. showed growth; while those which were run for thirty-five minutes were nearly all found to be sterile. No cans which had been given forty minutes spoiled, even when subjected to most favorable conditions in an incubator. The percentage of spoiling in all our tests was much greater than would have been the case had the cans been allowed to stand at a normal temperature, as in actual business practice. In all our tests the cans have been subjected to a constant temperature of blood heat (98 degrees F.) in an incubator, for over two months.

It is interesting to note that in these tests we have found that where spoiling occurs in peas processed for fifteen minutes or less at 236 degrees, in nearly every case the cans were swelled, while those which had been processed for more than fifteen minutes, and still showed bacterial growth, were for the most part sour in taste and acid in reaction, but showing no indication of swelling. The reason for this is that the gas producing bacteria are killed by the longer heating while other species, more resistant to heat but not able to produce gas, are not destroyed and later bring about the generation of the acid.

When it was first found that only about ten minutes is necessary to bring the center of the cans up to 236 degrees F., we thought that the time of sterilizing could be considerably reduced, as in our previous experience with corn we had found that ten minutes, after the heat had penetrated to the center of the can, was sufficient for sterilization. But it must be borne in mind that the temperature at which peas are processed is somewhat lower than that used in the packing of corn, and the time of heating necessary for sterilization must be much longer. Thus germs which require ten minutes at 250 degrees F. to be killed may require twenty to twenty-five minutes at 235 degrees to produce sterilization. Our retort experiments on corn showed that at the end of forty minutes at 250 degrees a temperature of 236 degrees was reached at the center of the cans, so that corn which received sixty-five minutes was getting twenty-five minutes at or above 236 degrees, which is practically what the peas are receiving when run thirty-five minutes at 236 degrees. Allowing ten minutes for the heat to penetrate to the center of the cans, they then got twenty-five minutes at this heat throughout.

By referring to our table on the retorting of corn, it will be seen that, if processed at the same temperature as peas, it would take eighty-five minutes to produce the same relative effect, as it requires sixty-five minutes for this heat to reach the center of the cans of corn.

Sweating.

If peas are allowed to stand for several hours about the factory, and the conditions are favorable, sweating will result, and this we believe to be largely responsible for sour peas.

We carried on a great many experiments along this line, and on opening the cans in every case we found sour peas. In this connection we brought out a striking fact; that is, that after sweating for several hours or over night the peas which have already become acid or sour may be sterilized in a much shorter time than fresh ones. A large majority of cans which were given but twelve minutes showed no further growth, nor did they swell. All cans retorted for more than fifteen minutes were found to be sterile, although, of course, sour. These results are probably due to the combined action of two factors, the acid already developed together with the high heat, as hot acid solutions are more effective than hot water in killing bacteria. Moreover, lactic acid is germicidal and by its long continued action would bring about the death even of those organisms which produced it. It is also probable that while sweating is taking place the germs multiply with great rapidity, being present on the surface of the peas not as spores but in the vegetative state, and so more easily destroyed.

The peculiarity just mentioned was especially observed with young and tender peas, while, as would be expected, the older and tougher ones required longer cooking than the young ones. This influence of the age of the peas on the time required for processing has also been noted in peas packed "normally," that is in the ordinary way without previous sweating. The difference, both in the case of peas which have undergone sweating and normal peas, appears to be due, in part at least, to the fact that in the young peas the amount of sugar is greater, while starch is more abundant in the older ones, and this sugar is not only more readily fermentable, giving rise to larger amounts of acid in a given time, but its conducting power is also greater, and so allows the thorough cooking of the peas in a shorter time.

Inoculation Experiments.

After making the experiments just described in which peas had been allowed to undergo sweating, we next inoculated living germs into cans of fresh peas and subjected them at once to treatment in the retorts, without giving any spores which might be present a chance to germinate into vegetative forms. As would be expected, in the cans given short periods of heating, some spoiling took place, but all cans given the full period of thirty-five minutes at 236 degrees remained sterile, and subsequent cultures made from those cans proved them to be free from living germs. The germs used in these inoculations were of species originally found in sour peas, and hence desirable to use for this purpose on that account.

Effect of Locality.

We also experimented to ascertain if there was any difference in the keeping qualities of peas from different localities, providing they had been given the same treatment. The localities selected for these comparative

tests were three in number and from eighty to one hundred and fifty miles apart. At two of the places certain differences of procedure from that employed at the third, where most of our work was done, were noted, but in so far as possible the conditions were made alike for all three places.

The percentage of spoiling was less in one instance than at the home factory and was somewhat higher at the other place than at either of the other two localities. The reason for this difference seems to be plainly in the methods employed at the various places. At the factory showing the smallest loss, the peas are not brought to the factory on the vines, but the pods are picked off in the field, and delivered in baskets. Consequently they are not run through a "viner" and exposed to a constant contamination from the dust and dirt which are always present on the vines. Another advantage of the "podder" lies in the fact that the peas do not get wet and sticky from the juice of the vines, but remain dry and so may be more quickly and easily cleaned, thus shortening the time before the peas are in the cans.

At the factory showing the largest loss the conditions were somewhat different. The machinery was admirably arranged for convenience, but it appeared to us rather too crowded to allow of perfect cleanliness. The old vines were also allowed to accumulate in large piles close to the factory and this we regard as a source of danger.

Any statement as to the saving of time in processing as a result of cleanliness is unnecessary, since every packer knows that a good product can only be obtained by the exercise of greatest care and cleanliness. We will summarize the conclusions drawn from our experiments as follows:

Thirty-five minutes at 236 degrees is hardly time enough to completely sterilize peas when packed in the usual way, particularly if they are old and hard. At the time now given, when the cans were placed in a favorable temperature, a small percentage was found which gave bacterial growth and an acid reaction.

We would recommend that they be given forty minutes at 236 degrees, or thirty-five minutes at 240 degrees. Should any souring occur in goods which have been processed at the above temperatures, it would seem to us that the peas had soured going into the cans.

So far as we can determine from the experiments made at different localities, the difference in the keeping qualities of the peas seems to be in the cleanliness of factory and machinery, and the celerity with which the goods are taken care of, rather than in any quality of the place itself.

CHAPTER VI.

In February, 1902, the various canners' associations in convention assembled at Milwaukee. The meeting was generally considered one of the most favorable ever held, both from a pecuniary standpoint as well as for the value of the scientific papers read.

The question of preservatives in foods having received considerable public attention, probably due to the various state food laws and press agitation, Professor Prescott was invited to discuss the subject, which he did in the following able manner:

PRESERVATIVES AND THEIR USE IN FOODS.

If we compare the processes of food preservation in use today with those commonly practiced thirty or forty years ago, we shall find not merely a considerable increase in the number of methods thus employed, but also an immense development in the application of methods known at that time. While as a whole the development of these methods has been of great benefit to mankind, it has also given rise to some of the most perplexing and difficult questions which have ever been put to the sanitarian or hygienist for solution, and one of these concerns the use of antiseptics. This particular subject has been for a long time a source of much contention, and its satisfactory solution is far from having been reached at the present time. It may be of interest, however, to inquire briefly into the present status of this question, and its bearing upon the subject of food preservation. In order to view this matter in its proper perspective some general statements as to the methods and aims of food preservation may not be out of place. It is almost unnecessary to state that the general aim in all these processes is the same, namely, to prevent putrefaction or fermentative changes, and thus to make the surplus of food of one place or one season available in another place or at another time, or in other words to guard against periods and regions of scarcity by conservation of the excessive supply in periods and regions of abundance.

Let me first briefly explain the cause and nature of fermentation, putrefaction and decay. Unless some means is taken to prevent, practically all foods are likely to undergo certain changes caused by the action of extremely

L. of C.

minute living organisms, variously known as germs, bacteria, microbes, baccilli, etc., or by the so-called unorganized ferments. All the chemical changes thus brought about by the activity of micro-organisms we sometimes designate as fermentation processes, although it is more convenient in general to subdivide them into the two classes fermentations and putrefactions. By fermentations we mean those changes taking place in sugary or starchy foods, the microbes transforming these substances into acids for the most part, and thus giving rise to "souring" as in sour corn and sour peas. Putrefactions on the other hand are the changes which are brought about by the bacteria in the more complex proteid or albuminoid foods, as meats, which are rich in nitrogen. Here, instead of the formation of acids, there may be a great variety of products, malodorous gases, and other bad-smelling compounds, and sometimes poisonous bodies, the so-called ptomaines, which if taken in with the food give rise to sickness and symptoms of poisoning. The bacteria causing putrefaction live anaerobically, i. e., they do not require free contact with the air. Decay is a term sometimes used in a broad way to describe any of these processes, and sometimes used in a more specific sense to indicate the changes taking place in albuminous matters in contact with the air, in which case no bad-smelling compounds are formed, unless putrefactive processes are going on within the food at the same time.

Of the processes which may be employed to bring about this conservation, we may easily distinguish four kinds of primary importance:

1. Cold storage.
2. Preserving, pickling and drying.
3. Canning.
4. The use of antiseptics.

The desired result may be obtained by the use of a single one of these methods, the choice depending upon the character of the food to be preserved, or they may be used in combinations to a certain extent, in which case the fourth method is generally combined with one of the others. Let us now briefly examine these four methods separately, and determine the underlying principle in each.

Cold Storage.—It is a well known fact that practically all kinds of food "keep" better in the cold than in warmth, and it has become a general practice to use ice to assist in the preservation of our daily foods. In addition to the convenience and general usefulness, there is a sound scientific principle underlying this practice, for we find that the micro-organisms of fermentation and putrefaction are so much weakened or so stiffened by cold as to be rendered inert, and therefore, for the time being, absolutely harmless. Obviously, this method can be employed only when it is desired to conserve materials for comparatively short periods of time, although with proper refrigerating machinery and chambers, some classes of food stuffs might be kept forever. This method is of inestimable benefit, for by it we are able to keep many foods in the fresh condition for considerable periods, and even transport fresh foods for long distances, which would be absolutely impossible but for the perfection of this process. It should always be borne in

mind, however, that refrigeration is not a process of sterilization, for when foods taken from cold storage are brought again to moderate warmth, the processes of decomposition begin as vigorously as ever, consequently foods should always be consumed or cooked immediately after leaving the cold chambers. This method is then a process of prevention of the growth and activity of microbes, not of sterilization.

Preserving, Pickling and Drying.—The processes which may be here classed as analogous in a general way to the preceding method, inasmuch as they are not sterilizing processes, but depend for their efficiency upon so modifying the physical properties of the food substance that bacterial growth cannot take place. In order that germs may develop abundantly a comparatively large amount of water is generally necessary, and if the percentage of water is diminished, as by drying, the germs are not able to bring about their changes until the conditions again become favorable for growth. In pickling in brine and preserving with sugar a slightly different action takes place, for here we increase the density of the medium by the addition of these substances which have a strong affinity for water. The dense solutions thus formed easily set up osmotic action and tend to absorb more water. When microbes come in contact with such substances the water is extracted from their bodies and they are thus rendered inert and innocuous. But as with the cold storage of foods protection is afforded only temporarily, for if we weaken the strength of the brine or sugar sufficiently, we find that the vitality of the bacteria has been merely diminished, that in reality we have had a case of suspended animation, and fermentative processes will go on vigorously.

Canning.—We come now to a method of food preservation which is of the very highest importance and value. While by the use of the foregoing methods it has been possible to establish a temporary immunity against the attacks of the fermentation microbes, by hermetically sealing the foods in cans or jars and subjecting them to sufficiently high heat we may guard permanently against any such invasion. In other words, if we *sterilize* our food materials we have no need to fear decomposition or fermentation for we have destroyed the cause of such changes. As has been repeatedly pointed out by Mr. Underwood and myself absolute sterilization means the killing of all bacteria, thus we have here the most nearly ideal of all preservation processes in actual use when considered from the fermentation and sanitation expert's point of view. This subject has already been so thoroughly discussed that further comment at this point is unnecessary.

Use of Antiseptics or Preservatives.—We come now to the last of the list of methods which I mentioned, and the one which must be viewed with the least degree of satisfaction and confidence because of the grave questions as to the effect of the chemical substances used as preservatives upon the health of the consumers.

By a preservative or antiseptic we mean a chemical substance which, owing to its toxic or poisonous action on micro-organisms, is capable of retarding or preventing fermentation and putrefaction. If the toxicity is sufficiently great to *kill* the organisms we speak of the substance as a disinfect-

ant. The distinction between a disinfectant and an antiseptic is then a difference in strength and killing power, for in very small amounts the strongest poisons act only antiseptically, that is they do not produce the death of the germs. Preservatives such as are used in food substances are all antiseptic in their character, but it is evident that not all antiseptics can be used as preservatives. The preservatives in common use, although sold under a variety of names, are in reality comparatively few in number as shown by the analyses which have been made from time to time. The most important of these are boric or boracic acid and borax, salicylic acid and sodium salicylate, benzoic acid and sodium benzoate, fluorides, sulphites, and formaldehyde. Borax or boric acid or mixtures of the two are extensively employed in the preservation of meats, fish, and dairy products. Salicylic acid and its salts are used for fruits and vegetable products chiefly, as jams and jellies and in beverages. Sulphites are used in the same food substances as salicylic acid, and also to some extent for meat. Benzoic acid finds use in beverages and fruit and vegetable preparations such as catsup. Formaldehyde is especially used for milk, and fluorides are used in some beverages, especially beer.

From the authoritative analyses of sixty-seven preservatives it was found that thirty-three contained either borax or boric acid as the most active constituent; ten contained sulphites; eight salicylic acid or its sodium salt, and seven benzoic or its sodium compound, while the others were either mixtures of the foregoing or were composed of other substances. Analysis has also revealed the fact that dealers sometimes sell a single compound or mixture under different names and at different prices, and often these substances are described as harmless and at the same time of the highest germicidal efficiency. It may also be of interest to know that all the preservatives commonly used in foods can be easily detected by the skilled chemist in spite of the statement sometimes made by agents that certain of their wares baffle chemical examination, a virtual acknowledgment that they are to be regarded as suspicious.

But of all the questions relating to the use of preservatives that of the effect of the substances which they contain upon the health is of greatest moment, and is likewise the most difficult of solution. Generally speaking those substances which exert a harmful effect upon bacterial life will produce a similar effect upon higher organisms although it may be to a much less degree, and this fact forms the basis of practically all objections to the use of antiseptics. That is, the general effect of such substances on living things is similar, although differing in intensity of action. For example, corrosive sublimate is one of the strongest bacterial poisons known, and also one of the chemicals most deadly for human beings, when taken internally, and the same rule holds good for practically all the substances of very strong antiseptic or disinfectant character. Obviously nothing should be added to foods which is in itself inimical or poisonous, or which interferes with the normal processes of indigestion. And here it should be borne constantly in mind that the old saying, "What is one man's meat is another man's poison," fits

the case exactly. It may be possible, perhaps, for strong, healthy individuals in good condition to eat foods containing a small amount of toxic antiseptic without suffering any serious consequences therefrom. It is entirely another matter, however, when invalids or delicate young children are given such foods, and the result is likely to be far from desirable. Further than this we do not know with certainty as to the cumulative effect of these substances, that is, whether they are readily taken care of and excreted, or whether they are retained within the body until considerable amounts have accumulated. We do know, however, that in large doses these substances almost invariably act harmfully, and consequently we should be led to believe that accumulation would give rise to the same results. To illustrate this in a crude way, there is probably no one here who would claim that a single drink of whisky would do any one of adult age and fair health any harm; on the other hand, there is probably no one in this hall who would deny that the same amount taken once an hour would seriously damage, and the same amount every ten minutes would soon destroy the most robust. On the other hand, it is also possible to conceive that some of these substances are no more harmful than common salt, but this is at least doubtful.

On reviewing a large number of articles written upon this subject during the past two years, I have been very strongly impressed with the inconclusiveness of the arguments presented, and these articles have been written by many well known physiologists in Germany, France, England and America. For example, Liebreich declares that boric acid and borax have no harmful effect when consumed in small quantities, while almost at the same time, in another journal, Halliburton asserts that all preservatives should be forbidden by law. Lebbin and Kallman made experiments on animals to show that sulphites were absolutely harmless and less poisonous than salt and state that the "toxicity of neutral sulphites is a legend." On the other hand, Lange and also Gruber object to their use on sanitary and hygienic grounds. In a similar manner Tunnicliffe and Rosenheim proved to their own satisfaction that boric acid, and even formaldehyde exert no harmful action upon healthy children, while Kister, in a very carefully conducted research, arrives at an opinion diametrically opposite. I could go still farther, and cite other examples, but without finally settling the question in dispute. Enough has been said, however, to show the present status of the question. In spite of the large amount of work which has been bestowed upon this question the discussion and experimentation have hardly passed beyond the academic or theoretical stage, and there is great need for the more practical demonstration before we should accept the use of these substances as harmless. I believe it to be the wise course to regard every chemical preservative as guilty until proved innocent. A little thought will show how difficult accurate, reliable experimentation must be in this matter, for a living body is a far more variable reagent than a chemical solution and, moreover, different individuals or animals must of necessity react differently according to their state of health, powers of digestion, occupations, and so forth. Then it will be neces-

sary to make an enormous number of observations before the matter can be regarded as settled.

It is true that there is a class of food products such as ham, bacon, dairy products, jams, etc., of such character that their flavor or usefulness would be destroyed by heat. For such foods harmless preservatives would be of inestimable value, and use of preservatives in such foods has a poor excuse on the ground that the antiseptic is necessary to prevent decomposition. In such cases every package should be plainly labeled with the name of the antiseptic it contains. In canned goods, on the other hand, the use of any antiseptic should be unhesitatingly condemned, for it is absolutely unnecessary if the food has been properly prepared and sterilized. Addition of any preservative to canned foods is a virtual acknowledgment that the packer does not know his business, and their use can only be regarded as a makeshift to cover up slovenly, uncleanly and inefficient methods. The absence of preservatives in canned goods is an indication of good, intelligent management, cleanly methods and wholesome food as a rule. On the other hand their presence shows the reverse characteristics and a tendency to carelessness and sloppiness on the part of the manufacturer, for if a manufacturer depends upon the use of a preservative to ensure the keeping quality of his goods, he is putting a premium upon inefficient and careless work.

Whether preservatives are ultimately proved to be injurious or otherwise their use in canned goods should never be allowed for the simple reason that they are unnecessary if the goods have been properly prepared.

In the different States there are numerous laws regulating the use of these chemical antiseptics in foods. As these laws are different, a man might conceivably be acting within his rights in one State and violating the law by selling his product in another. At the present time the only way to be sure of being on the right side is by abstaining entirely from the use of antiseptics, for here as in all things else total abstinence is the only absolutely safe method of keeping out of danger.

It is probable, perhaps, that their use cannot be entirely prevented, consequently a national law regulating the use and restricting abuse of such substances is most to be desired. That this subject is of international or universal interest is made evident by the amount of discussion which has been given to it in England and on the continent. The latest contribution is in the report of the committee appointed by the British government to investigate the use of preservatives and coloring matters in foods, and which has been recently published. The report of the committee is on the whole unfavorable to the use of preservatives, recommending that certain ones be entirely prohibited and that others when used at all should be only in extremely small quantities, certain maximum limits being set, limits so low, by the way, that there might almost be doubt in some cases as to whether any preservative action at all would take place. It is interesting to note that the report insists that no preservative of any kind should be used in any dietetic preparation intended for the use of infants or invalids, and also prohibits the use of copper salts in "greening" of vegetables, although one member of the committee

demurred from this judgment. Comment upon this excellent report is almost unnecessary, except to say that it emphasizes anew the unsettled state of the question and the necessity for much further experimentation before anything like a final verdict can be pronounced.

The prohibition of the use of preservatives in foods designed especially for infants and invalids betokens some suspicion on the part of the committee that there is no chemical preservative which is not objectionable under some circumstances.

In conclusion let me reaffirm the necessity for more information upon this important subject. I believe it would be wise for such bodies as this association to take whatever steps may be within their power, toward further investigation, either by agitation for a national court of inquiry similar to that recommended by the English report, or otherwise. The agricultural department has already done much in this direction, but more could be done if the manufacturers of such foods would show a spirit of something more than selfish interest, and use their power to further the work. In my opinion, such action on their part would be fully repaid, even in a financial way. And especially let me emphasize again that the two best agents for preservation of foods that are at our disposal are cold and heat, cold for the fresh foods which are to be kept temporarily, and heat for the greater and ever-increasing class of canned goods, which can be kept for any length of time and in all climates, and which already plays so important a part in the nutrition of the world. If the producers of canned foods are wise, they will study to secure complete sterilization by heat, cleanliness, rapidity and economy of production, and intelligent, scientific management of their factories. They will thus have no use for preservatives, but will regard them as undesirable because absolutely unnecessary, for there is no valid reason that can be suggested for the addition of a substance of dubious influence upon the health of the consumer to what should otherwise be regarded as a pure food of the highest value.

THE ECONOMIC AND SANITARY IMPORTANCE OF CLEANNESS IN THE CANNED GOODS INDUSTRY.

Mr. W. Lyman Underwood of the Massachusetts Institute of Technology read his address to the convention, illustrated by stereopticon views, which was listened to with much interest by the convention. Mr. Underwood spoke as follows:

When I entered the banquet hall last evening I felt something like a cold chill on finding the name of Underwood on the program as having something to say about "Those Who Can and Do." I had made no preparation and felt quite cheap, and did not know what I could say about "Those Who Can and Do." The only thing that came into my mind was an old Scotch saying, "Granny, a man may can all the corn he can, but the canner can not can a can." I found later that there were other Underwoods than myself and I was not called on at all.

Thanks to the science of Bacteriology, which has made such rapid strides in the past few years, there should be no longer any uncertainty as to the reasons why spoiling sometimes occurs in certain canned goods. The science has shown us that such deteriorations are due to the presence of minute organisms variously known as micro-organisms, germs, microbes or bacteria. They comprise the lowest and smallest forms of life. So small, indeed, that thousands might find standing room, so to speak, on the point of a cambric needle. It was previously thought that these lower forms were generated by decomposing organic matter which, in some unaccountable manner, had the power to spontaneously produce this type of life.

It was even believed that putrid meat had in itself the property to produce worms or maggots. Many years ago they went even further. Someone claimed that, given a quantity of dirty rags and some pieces of cheese or crumbs of bread, mice could be spontaneously generated.

For many years a fierce conflict waged between the upholders and disbelievers in this theory of spontaneous generation; until Pasteur, by a series of continued experiments carried on for many years previous to 1880, demonstrated beyond all possible doubt that these lower forms of life could not be generated anew, but must always come from previous existing life. By these experiments he showed how easily these germs could come in contact with all organic matter and as a result of these discoveries better methods have been devised by which it is possible to guard more thoroughly against the action of germ life.

One of the principal weapons of defense against this bacterial action is the practice of most scrupulous cleanness, and in no other industry does this factor play a more important part than it does in the preservation or canning of food products. While, no doubt, it is generally considered that cleanness is a most desirable state in any manufactory there are certainly more important and vital reasons why such a condition should exist in the operation of this business than in many others. No manufacturer cares to see his factory in a dirty condition, if from no other than aesthetic reasons. The presence of dirt and disorder, even if no direct hindrance to the proper performance of any business, is certainly an offense to the eye. In factories where a lack of order and cleanness exists the operatives will be likely to form their habits and carry on their work in a manner somewhat corresponding to their surroundings. In the canning industry, however, cleanness is necessary from other and more weighty considerations than the mere aesthetic ones, and it is the purpose of my paper to show why this is so and to make some suggestions bearing on the subject, which I hope may be of interest.

The fundamental principle involved in the preservation of food in cans or other hermetically sealed packages is the exclusion of all germ life from contact with the food material in such manner that it shall be impossible for any germs to gain access to the contents of the package. In order to remove all bacterial life which, under ordinary conditions, is everywhere present, especially upon food products, heat is employed as a means of sterilization and through this agency these lower forms of life, the active principle of all

decay and fermentation, may be killed. While all bacteria may be readily destroyed by the proper application of heat, as has already been pointed out in the previous papers read before you by Mr. Prescott and myself, it is important to know just what temperature is necessary or how long a given temperature should be applied to overcome the specific organism which is concerned in any particular food to be preserved. Some microbes are much more susceptible to heat than others. Many of them will succumb to a temperature of 200 F., while others will survive after many hours of cooking at a boiling temperature. Fortunately the pathogenic or disease germs belong to the class which are easily killed; unfortunately for the packers, however, the germs which are most liable to cause trouble in their industry are those which are the most resistant to heat. To overcome some of these more tenacious germs may require a more intense or longer continued heat than is practical to use without over-cooking and thus injuring the flavor of the food. Under these circumstances it is easily seen how absolutely necessary it becomes to use every precaution in preventing, so far as possible, any bacteria from coming in contact with the food before it is put into the cans. The particular danger to be apprehended is that the germs may be easily transmitted to the food through the agency of dirt; for dirt is the principal vehicle by which bacteria may be readily conveyed.

In this paper we shall consider as dirt not only soil and earth, but, in addition, those substances from whatever source which become of significance because of their possibility to act as carriers or transmitters of bacterial life. Broadly speaking dirt may be well defined as matter out of place, and under this general heading might be included material varying quite widely in character and originating from very different sources. This definition is much broader than the generally accepted one that classes dirt merely as soil or earth, and regards it as matter entirely without life. The common opinion that soil and dust are lifeless matters is an erroneous one. In reality "it is one of the most marvelous revelations of bacteriology that the earth long regarded as the type of lifelessness is in fact at least in its uppermost layers teeming with life, containing vast hosts of micro-organisms more abundant by far than the grains of sand upon which they dwell. A single gram of garden soil (approximately half a teaspoonful) may contain millions of micro-organisms."

So long as these bacteria remain upon the ground as a part of the soil they are very beneficial, for they constantly help to decompose organic matter and change it into food for vegetation. When, however, they gain admission to the factory and bring about decomposition of the rich food material upon which they may be deposited, unless destroyed by thorough sterilization (for many of them have great resistance), they will cause changes, fermentation and bad flavors.

It may be even possible, provided the weather is warm or if the cans stand around for a considerable time before they go to the retorts, for the germs to grow sufficiently to produce some undesirable change before the final processing. It is thus readily seen how easily these conditions may

cause economic or financial loss. It might be wondered how these organisms could gain access, in any considerable numbers, to the factory. The problem is a simple one, however, when it is considered, as has already been stated, that the upper layers of the earth are so densely populated with germ life. In dry weather any current of air will lift more or less dust, conveying it to distances varying with the strength of the wind and with a strong breeze the number of bacteria so carried may be enormous.

In some experiments conducted by Professor Sedgwick, at the Massachusetts Institute of Technology, it was found that in a gallon of air taken during a dust storm, five feet above the surface of a macadamized road there were present approximately 100,000 bacteria. Thus it will be seen how easily this type of dirt, which we may call earth-dust, containing its vast numbers of bacteria, may, under favorable conditions, get into the factory. To minimize the danger from this source it is important to do away, so far as possible, with all conditions about the factory and immediate vicinity which tend to give rise to dust. Sowing grass and keeping a good turf about the building and using as little area as possible for roadways, and keeping these well watered will do much to mitigate this evil.

Still another type of dirt frequently gives rise to further trouble, the source of which lies in the uncleanly habit of allowing refuse, as for example, piles of corn-cobs or pea-vines and pods, to accumulate close to the factory. In warm weather this refuse, quickly fermenting, generates millions of bacteria and attracts countless numbers of flies, who, feeding upon and walking over the fermenting material, may carry away these germs upon their feet. Flying into the factory they now infect any food material upon which they happen to light. An illustration of this fact will be shown you later by the stereopticon.

It may not be out of place in this connection to say a few words in regard to the common house fly, when it is seen how easily this insect may become a menace to the packer, aside from the fact that it is always an unmitigated nuisance to everyone. Dr. L. O. Howard, chief of the Division of Entomology at Washington, D. C., states that 99 per cent. of the flies which are found about houses and stables are the ordinary house fly, Musca Domestica, which occur in enormous numbers and are wonderfully prolific. An individual fly lays on an average about 120 eggs, which in a few hours hatch into larvae or maggots. Then, after another transformation, at the end of ten days becomes eventually the full grown adult insect. It has been found that these flies breed almost exclusively in horse manure, as fully 95 per cent. of all of them come from this source and experiments have shown that a single pound of horse manure will produce 1,200 flies.

It will be seen that it is dangerous to allow such waste material to accumulate about the factory. The remedy in this case is an obvious one. Get rid of such refuse at once. To be freed of the flies, however, is not so simple a matter, although a complete removal of all waste material will, no doubt, cut down their numbers considerably. If there are many horses used in connection with the establishment or stabled in the near vicinity, the plac-

ing of fly-screens around the manure pits will effect a radical change in the conditions by keeping out the flies from their natural breeding-places. The liberal use of chloride of lime sprinkled over the manure, where it is not practicable to use screens, will tend to produce the same result.

Having considered the principal sources from which germs may be brought into the factory from the outside, it now remains to take up the liability of trouble occurring through a lack of cleanness within the factory. It is hard to say which of these two sources is the more important for in many ways they are dependent on one another. The greatest danger in the factory and probably the most common one arises from dirt in the form of fermenting food material. For example, in the canning of sweet corn, any kernels or milk of the corn that happen to be left upon the floor or on the cutting, silking and cooking machines or upon the utensils used to convey the product about the factory will quickly ferment. Each particle now becomes a centre from which germs may be further distributed, until as with yeast in bread making "A little leaven leaveneth the whole lump."

The rapidity with which these particular microbes will multiply under favorable conditions is shown by the experiment which was described in the paper on Sweet Corn, written by Mr. Prescott and myself. I may be pardoned for repeating it for it illustrates this point very strongly. Into each of two cans of fresh corn was placed a very small drop of liquid containing some of the bacteria obtained from kernels of corn. These cans were then sealed and put in a warm room at 9 o'clock in the evening. At 6 next morning it was found that at some time during the nine hours intervening both cans had swelled and burst, literally tearing the entire top from the cans and covering the ceiling with kernels of corn.

Similar results have been observed in the packing of peas; in fact the growth of germs in this case may be even more rapid than with corn, and it is no doubt the principal factor concerned in producing the peculiar flavor in sour canned peas.

To guard against the danger from fermentation of raw material which has been left upon the machines or scattered about the floor, it is necessary to give frequent and thorough washings to utensils as well as machines and floor, using liberal quantities of scalding water or live steam at least twice a day. In well-managed factories where this is already the custom, the excellent results well repay the additional labor.

In the packing of peas the ordinary method of removing them from the pods by the viner machine introduces another complication. It is hard to imagine a more fruitful source of contamination than that afforded by this machine. Vines and leaves, pods and peas, just as they are cut and brought from the fields, are run through it, and by revolving wooden paddles the peas are thrashed out from the pods. Dust and dirt abound, and must of necessity come in direct contact with the peas. Nevertheless, by the use of this machine such a tremendous amount of labor is saved that it is hard to see how it could be dispensed with, as the shelling of the peas by hand would be a most expensive and slow operation.

The only remedy to be applied under the circumstances is to scald the peas at the earliest possible moment after they come from the viner. This will check the growth of most of the bacteria, and if promptly done no bad flavors should develop, provided the heat in the final process be high enough for thorough sterilization.

The remaining danger of contamination to be considered is that arising from the dirty hands of the employees; but this defect is easily remedied, where it exists—and there is really no excuse for its existence. Men, women and children who will not conform to cleanly habits should have no place in a canning establishment. Their room is far better than their company.

Encourage their keeping themselves clean by providing them with suitable and convenient toilet rooms, well supplied with soap, water and clean towels. Cleanness and order from attic to cellar will invariably induce cleanly habits with all who labor under the same roof, and employees will soon take pride in working under such conditions.

CHAPTER VII.

Professor Forbes of the Illinois State University read the following

CONTROL OF INSECT INJURY TO CORN.

paper on the above subject at the annual canners' meeting held at Detroit February, 1900:

Professor Forbes spoke as follows:

The subject of corn insects is very complicated, one which has been investigated by students for many years. The time I have spent upon it myself is more easily reckoned in years than in months. I can touch only upon a few cursory points in corn culture. I can speak of only a few of the preventive measures which everyone should know who is interested in this subject, and illustrate my remarks by a few drawings of the leading corn insects.

The struggle between man and the insect world, begun long before the dawn of civilization, has continued without cessation, and will continue, no doubt, as long as the human race endures. It is due to the fact that both men and insects want the same things at the same time; its intensity is owing to the vital importance to both of the things they struggle for; and its long continuance is due to the fact that the contestants are so equally matched. We think of ourselves as lords over nature and masters of the world, but insects had thoroughly conquered the world and taken full possession of it long before man began the struggle. They had consequently all the advantage of a possession of the field (which is nine points of the law) when the contest began, and they have disputed every step of our invasion of their ancient domain so persistently and so successfully that we can even yet scarcely flatter ourselves that we have gained any very important permanent advantage over them. Here and there a truce has been declared, a treaty made, and even a partnership established which is advantageous to both parties to the contract—as with bees and silkworms, for example—but wherever their interests and ours are diametrically opposed, the war still goes on, and neither side can claim the final victory. If they want our crops they still continue to help themselves to them; if they like the blood of our domestic animals, they pump it out of the veins of our cattle and our horses at their leisure and under our very eyes; if

they choose to take up their abode with us, we cannot wholly keep them out of the house we live in, we cannot protect our very persons from their annoying and even pestiferous attacks, and since the world began we have never yet exterminated, we probably never shall exterminate, so much as a single insect species. They have, in fact, for ages inflicted upon us the most serious evils without our even knowing it. It is the cattle tick which keeps alive and propagates the Texas fever; it is the mosquito which inoculates our blood with malaria; it is the house-fly which carries to our food the typhoid-fever germ, and now that we have begun to discover facts of this order, it is likely that many more such instances will be brought to light. Not only is it true that we have nowhere really won the fight with the world of insect life, but we may go further and say that by our agricultural methods, by the extension of our commerce, and by other measures connected with the development of our civilization, we often actually aid them most efficiently in their contest with ourselves. Our rapidly growing world-wide commerce in fruits and grains, for example, our importations of new plants from the remotest regions of the earth, and our exports of our own best varieties in turn, have the practical effect to establish a general international exchange of injurious insects such that we are apparently certain to become the eventual prey of every insect species living anywhere on earth that can do us any harm.

To the attacks of these associate insect enemies, native and imported, the corn plant is in some respects seriously subject. In the first place it belongs to the great family of the grasses, to which nearly all the other farm crops, whether of grain or of forage plants, also belong. An American farm, except for the garden patch and an occasional field of clover, is usually an unbroken area of a few kinds of grass; and as several of our worst insect pests feed on the grass plants generally, Indian corn is exposed with the rest to the principal enemies of all. The wireworms, the cutworms, the white grubs, the army worm, the chinch-bug, the turf webworms, and the grasshoppers are all general grass insects which can find an abundant means of support anywhere and at any time, and which multiply without hindrance on almost any farm, and all are peculiarly destructive to Indian corn. Our pastures and meadows are, in fact, the great feeders and breeders of the worst corn insects.

Other serious difficulties are due to a common farm rotation, in which corn follows upon grass. In the turf of our pastures and meadows the principal grass insects may exist in considerable numbers without producing any very considerable effect on the abundant vegetation which carpets the ground and grows rapidly to make good any injury; but when corn follows on this infested sod, all the grass insects which come through the winter in a destructive stage, emerging in spring hungry from their long fast of hibernation, find no longer the abundant feast of a grassy turf prepared for them, but only the sparse vegetation of a field of sprouting corn, and on this, of course, they concentrate for its destruction—more or less complete. The cutworms, the wireworms, and the white grubs are examples.

Then besides these insect enemies common to the grasses, the corn plant has its own special list of dependent insects (such as the corn root worm and the corn aphis), which do little or no harm to any other valuable plant. As the so-called corn belt of America is a comparatively limited region, Indian corn is always a very prominent crop there and must become more prominent with each decade. This permanent devotion of a vast area largely to a single crop offers the best conditions possible for the inordinate multiplication and general distribution of these special insect enemies; and hence we have seen the two species just mentioned rise within the last thirty years from entomological rarities to agricultural pests, and we have been able to trace the extension of their injuries year by year to regions in which they had been previously unknown.

There is another source of difficulty and danger which the corn crop shares with some of the other principal crops of the farm, and that is a variability and uncertainty of entomological injury such that the ordinary corn grower will trust to luck for the safety of his crop rather than use either systematic precautions or special measures of prevention. If insect injuries were practically the same year after year, all would learn to guard against them, but since they may range from nothing to a hundred per cent. the farmer speculates on his chances of immunity, saving thus each year a slight expense and trouble, but incurring thereby a certainty of ultimate heavy loss. A correct general policy in respect to agricultural injuries by insects is a measure of crop insurance, but premiums must be paid in year by year, otherwise the policy lapses.

A general difficulty related to the foregoing and, like that, subjective to the farmer instead of objective to the insect or the crop, is due to this same general disposition to speculate instead of insuring. The farmer is necessarily and at best a great speculator. His profits always depend upon so many unforeseen and uncontrollable contingencies that from the day when he puts his seed into the ground until he pockets the proceeds of his labors and investments, he is practically betting on the occurrence of series and combinations of lucky accident. His tendency to bet on his luck is thus likely to become inveterate, and clings to him under circumstances where he should see that the game is already going against him. Then when general conditions are peculiarly favorable to an insect outbreak, he nevertheless frequently bets that all signs will fail, and that this time he will surely escape; and even after the outbreak has begun he may persist in betting that it will presently cease without doing him serious harm, so the time for efficient action is passed in optimistic speculation and the disaster becomes irremediable.

In fact, applying these remarks to the economic entomology of the corn field, we may say that in this field all disasters are irremediable. When an insect attack on corn has become serious enough to arouse apprehension, it is almost invariably too late to arrest it. There are no remedies, generally speaking, for the entomological diseases of the corn crop, and we are limited in our practice to hygienic, that is to preventive, measures only.

As an illustration of these preventive measures, to the value of which I

shall have frequent occasion to refer in the detailed discussion of injurious insect species presently to follow, I may mention a suitable general scheme of crop rotation. Throughout the greater part of my own state the favorite and long established rotation system is that in which grass, corn, and small grain follow each other more or less rapidly in the order named and in uninterrupted succession. Now what I have said of the injuries to corn due to insects bred in pastures and meadows must have already suggested to you the defective character of this rotation scheme from the standpoint of the economic entomologist. It is a scheme for the rotation of crops but not of crop insects. From grass to corn and from corn to small grain the same species carry over more or less completely and do a continuous injury, gradually diminishing in number, it is true, until the return to grass, but then rapidly regaining all their old abundance. What is needed is a variation of this rotation such as will break the vicious circle by the insertion of some crop not belonging to the family of grasses, and hence not likely to attract and breed the principal grass pests. And it is best that this should be a forage crop since, as I have already said, it is the forage grasses which furnish the great feeding and breeding grounds of the corn insects generally. A system then, in which pastures and meadows of blue grass, timothy and the like, should lie as long in grass as practicable, not entering into the ordinary grain rotation, but in which this rotation should consist of corn, small grain, and clover in continuous succession, would meet the conditions mentioned.

Then when the old grass lands are finally broken up for corn, special measures must be taken to clear them, so far as practicable, of hibernating insects before breaking, and clover or some other crop not itself a grass must, whenever practicable, be introduced before the ground is planted to corn. A very early fall or late summer plowing of the turf will prevent the appearance of cutworms in the field the following spring, and pasturing by pigs previous to plowing will destroy the greater part of the white grubs and wireworms living in the sod. Another measure of prevention, to which also I shall have occasion to refer again, is an early change of crop on corn land, such that the special corn insects shall not have too long a period in which to multiply up to destructive numbers. Signs of danger, recognizable by an intelligent observer, will presently be described; signs which call for an immediate shifting of corn culture to some other ground.

The corn insects recognized in the Eastern United States as in some way and to some extent injurious to some part of the plant number 214 species, of which 18 are known to infest the seed, 27 the root and the subterranean part of the stalk, 76 the stalk above ground, 118 the leaf, 19 the blossom—that is the tassel and the silk—42 the ear in the field, 2 the stacked fodder, and 24 the corn in store, either whole or ground. The greater part of this long list, which is doubtless by no means really complete, is composed of those whose injuries are now so slight or so rare as to constitute a possible menace rather than to cause a serious loss; but the history of economic entomology, and even of the entomology of this plant, teaches us

that we can rarely tell in advance what to expect of any possibly injurious species. In fact some of the insect enemies of corn now most destructive were not many years ago almost unknown even to the entomologist—the northern corn root worm and the corn root aphis, for example.

The principal insect species infesting this plant are the wireworms, attacking the seed; the same insects, the white grubs, the corn root worms, and the root aphis, affecting the roots; the cutworms and root web-worms, the army worm, the corn worm, the bill-bugs, the chinch-bugs, and the grasshoppers, injuring stalk and leaf; the corn worm, the corn root worms, and the grasshoppers eating the flower structures and the ear; and the meal-moth and the weevils devouring the kernel in the granary or the meal in the bin. Of these by far the worst at present are the wireworms, the corn root worms, the white grubs, the root lice, the cutworms, the chinch-bug, the corn worm, the grasshoppers, and the army worm.

Here are some drawings showing the northern corn root worm. It is a small worm which bores its way lengthwise in the young roots of the corn; it leaves behind a brownish colored trail in the passage way it eats through the root. By examining the roots of the young corn you will discover this. Of course the plants are weakened; those that are attacked have a stunted growth.

The corn root aphis is closely associated with the common brown ants found in corn fields. The ants collect the eggs in the fall and take them in their burrows in the ground, and there keep them all winter. In the spring they carefully watch the eggs; on warm days they are brought to the surface of the ground where they will be warmed by the sun, and at night are taken underground again, to protect them. By digging up in some corn field you may find in the ant's nests in early spring quantities of these eggs. As soon as the eggs are hatched they are taken by the ants and placed on the young roots of the growing corn; in themselves these insects or lice are helpless, and very sluggish in their movements. They feed on the tender roots of the corn; the ants are benefited in this way; they live upon a sweetish exudation from two tubes, one on each side of the lice at the posterior portion of the body; the ants themselves do not touch the corn, as many think, but simply live upon this sweetish substance from the aphis itself. The manner of reproduction is as follows: All the eggs which hatch in the spring are all females; the young are born alive, there being no eggs. They mature in about 12 to 14 days, and begin reproduction immediately. The number which could be produced from a single one of these lice, if there were no checks upon the number reproduced, is simply enormous. We estimated it once, and after taking measurements of the insects we found that the lice produced from a single one, in the course of a season, if reproduction was carried on at the same rate they are capable of, would produce a sufficient number to make a path ten feet wide and fifty miles long. While during the spring and summer only females are produced, and these are born alive, in the last generation in the fall there are both males and females brought forth; they pair then as other

insects do and the eggs are laid, which are collected by the ants, as above stated.

Here you see the white grub, and its egg, going through the various stages. Here is the pupa, and then the brown beetle which you have all seen in the fall. Both the wire worm and the white grub are grass insects. The white grub lives three years before it completes its transformations, so that the second year after the grass has been planted in the corn field there may still be found great numbers of these insects, the white grub and the wire worms; frequently the greatest injury is done the second year, so that it will not be safe even then to plant corn in a field which has been infested with them. The point I wish to make regarding these is that for the proper protection of the corn there should not have been corn in the field for two or three years previous, on account of the length of the life of these insects; clover should be substituted.

The root web worm is a cut worm; they result from eggs laid by moths in the fall, and complete their transformations in a single year; the eggs are laid in grass lands, and where there is no grass upon the ground the eggs are not laid. If the ground is plowed early the young have such a long time to live before there is anything for them to feed upon they will perish before there is food for them.

If you see rows of little holes in the leaves of corn, made very regularly as to size and position, like these shown here, you will know that they are made by the bill bug. These punctures are made when the leaf is young, and folded up so that all these punctures were made by one incision of the sharp bill of the insect, going through the several layers of the folded leaf. As the leaf unrolls in the course of its growth, the punctures appear side by side as illustrated; and these long punctures are caused by the growth in length of the leaf, the holes extending in length as the leaf grows. These bugs are very destructive; they are bred mainly in grass lands; the larvae will have on a single stalk and top of timothy sufficient food to bring it to maturity.

Here we have the several stages of the chinch-bug; the eggs are deposited in May on the roots or lower leaves of the corn. They shed their skin four times, and each time the general appearance of the insect is changed, making five stages. There are two generations in a year. Some live on the wheat and others on corn. We have demonstrated the practicability of the destruction of the chinch-bug to prevent it doing injury to corn. At the harvest period most of these bugs have not reached maturity; some have of course, but not very many. And not yet having wings they cannot make their way from one field to another; they concentrate upon the outer rows of corn along the field. They do not know the use of wings at first, and crawl along the ground, helplessly, in rows. The chinch-bug lives upon nothing but grasses; it cannot live upon anything else. We have found in experimental work and also in practice that this insect can be destroyed as it makes its way out of the field, at a very small expense. We killed all the chinch-bugs in a 20-acre field of wheat, as badly infested with this

pest as any field can be, at an expense of about 50 cents per bushel, and we gathered about 13 bushels of these insects from the field. We measured a quantity of them and estimated that there were about 8,000,000 of them to the bushel. The total expense of doing this was about \$5 or \$6, and we saved the field adjacent to this one. The process is a combination of the various methods in use into one. You have probably heard of the "dusty furrow"; these bugs cannot crawl over this furrow, made by dragging a log around in the furrow until the earth is made into a fine dust; they simply roll back when they attempt to climb up. Of course if a shower comes and moistens the earth, the dusty furrow is spoiled, and then they can go over. Another method is to pour a small stream of tar around the field. This will effectually arrest the progress of the grub. At intervals of about 20 feet in the dusty furrow the farmer can take a post-hole digger and dig holes of a slight depth, and the bugs will accumulate in these holes, where they can be killed by the use of a little kerosene.

Let me now recapitulate the economic recommendations of this discussion.

1. There is, generally speaking, no remedy for the attacks of the corn insects, and we are compelled to depend on measures of prevention only. Exceptions to this statement are offered by sudden invasions of the corn field from without by insects moving together on foot, such as the army worm and the chinch bug. The progress of these insects may be arrested by barriers interposed across their line of movement, and their destruction at such barriers as they accumulate there. Preventive measures are either general precautions to be applied without reference to locality or temporary condition, or special precautions to be used when special danger threatens. The former are generally measures of farm management, such as the rotation and selected succession of crops, and the choice of times for the plowing and the planting of the field. The latter are special variations of the usual management called for by unusual circumstances, such as the appearance in the field in fall of notable numbers of the beetle, of the corn root worm, or noticeable injury to corn by the wireworms in the spring of the first year after grass.

2. The use of clover instead of grass in the ordinary rotation of the farm will greatly reduce injuries to corn by wireworms, white grubs, cutworms, and turf web-worms, and the insertion of some other crop between grass and corn when a change from one to the other must be made, will reduce losses by insects under these circumstances to a minimum. Pasturing grass lands by pigs in summer and early fall before the sod will be similarly serviceable.

3. The very early plowing of grass lands—that is in late summer or in early fall—will prevent attack by cutworms and web-worms upon the crop of the following spring, except as these insects may invade a field to some extent from without, and fall plowing of land infested by wireworms will tend to prevent the transformations of those insects to the beetle stage, and will thus help in a general way to keep their numbers down.

4. Frequent change from corn to some other crop on the same ground

will diminish loss by the corn root aphis and prevent that by the corn root worm. Such change becomes imperative if the crop has suffered noticeably from the latter insect.

5. The chinch-bug may be so far kept out of the corn field as to make its injuries to corn comparatively insignificant by a combination of the dusty furrow and the coal-tar strip reinforced by post-holes, with kerosene emulsion reserved for use if this compound barrier is locally passed by the bugs. A still simpler form of this barrier method will serve for the exclusion and destruction of the army worm.

6. For the injuries of the corn worm we have as yet no preventive or remedial measure of any special value, but there is some theoretical reason to believe that fall plowing of corn ground will act as a gradual check upon them.

Finally, if we scan this program of operations and list of expedients we shall find them not only practicable at little additional cost to that of the ordinary management of the farm, but actually beneficial, as a whole, to the crop and to the farm itself irrespective of their utility for the prevention and control of insect injuries to corn. In fact, the conclusions and requirements of the economic entomology of this crop powerfully support the requirements of an intelligent agriculture, and if the insect enemies of corn do nothing more for us than to popularize the culture of clover as a substitute for the edible grasses and to enforce a frequent change of crops on the same ground, I think that they will in the end deserve blessing instead of cursing from the American corn farmer.

Prof. Forbes then answered questions of members regarding points brought up in his address. He said a fall plowing would not diminish all of the pests referred to, although it would some of them. By removing the fodder from a corn field and the next year replanting it with corn, will help to diminish a number of insects which interfere with those who raise corn for canning purposes. Fall plowing of infested fields breaks open the cells of the pupa and the insect is thus exposed to the weather, and they are not likely to survive the winter if exposed in this way; that is about the only benefit I know to be derived from fall plowing. along this line. A second plowing in the spring would undoubtedly be of benefit. Some sections are troubled with the corn root worm, and the farmers find that heavy fertilizing with manure helps the corn; but in such cases the increased growth of the corn is undoubtedly due to the effect of the fertilizer upon the corn, rather than any effect upon the worm. in the way of destroying the worm. Because the next year there will be more worms than before. The best way to get rid of them is by rotation of crops, as I have said. The damage is less in wet years than in dry seasons. because the corn grows so much faster, the effect is not so observable. But if you fertilize very much you will simply raise a heavier crop of worms.

There is no fertilizer or substance which can be dropped in the hill of corn and destroy the worm or its effect upon the corn—that is, I do not know of my own knowledge of such a fertilizer which will kill any insect. We have experimented along that line, and have used the super-phosphates

saturated with crude petroleum, and muriate of soda, and other preparations of petroleum, with the idea that we would get the fertilizing effects and the insecticide effect of the petroleum. But I do not know of anything which will destroy insects by application to the crop itself.

CHAPTER VIII.

PEA PESTS.

The pea vines during the years 1899, 1900 and 1901 were severely afflicted with an insect which materially damaged the crop and in some cases ruined whole fields. The habits and character of the insect were practically unknown to canners and even entomologists were puzzled to account for it. The sections first affected were New Jersey, Delaware and Maryland, and a year later the insect found its way to the western fields of Indiana and later into Wisconsin. The canners in the states first affected naturally turned for aid to their several state agricultural stations and it is to the efforts of Professor W. G. Johnson of Maryland and Professor J. G. Sanderson of Delaware that a means has been found for treating the pest.

The following paper by Professor Sanderson was read at Detroit February, 1900, before the convention of eastern and western packers:

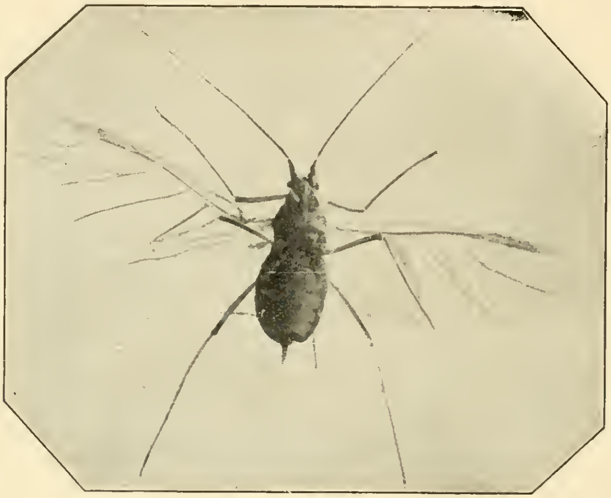
THE DESTRUCTIVE PEA LOUSE.

It certainly has been many a year since any branch of the packing business has been so affected by an insect as was the pea industry during the season of 1899. From North Carolina to the Bay of Fundy the pea crop, hitherto but little annoyed by insect pests, was blighted by the attacks of the destructive pea louse. The injury was most complete in Maryland, Delaware and adjoining States. In Maryland many hundred acres were a total loss, and in general from 50 to 75 per cent. of the crop was destroyed. In Delaware about 45 per cent. was lost, while in New Jersey the attack was not so severe.

The unusual amount of damage done would be sufficient in itself to call attention to this pest, even were it one previously well known, but when we find that this species was hitherto absolutely unknown, our interest is at once aroused concerning this insect capable of such sudden and widespread devastation. As regards the origin of the pest practically nothing is known. For two or three years past it has done more or less damage to late peas in individual localities, but never of considerable importance. The family of plant lice or aphides, to which this insect belongs, is one but little known to most entomologists, so that the insect may have been feeding on some com-

mon weed for many years without having been noticed. No such species has been described from Europe, although it might possibly have been imported from some other clime. However that may be, the species was never noticed as such until the present year, and has not even yet received a technical description. Prof. W. G. Johnson, state entomologist of Maryland, has given the insect both its common name and scientific title—Nectarophora destructor, Johns—and it is to him that we are indebted for much of our information concerning it.

The damage being done by the pest was first noticed about the middle of May, 1899, and from that time until midsummer it became increasingly injurious. The first case to be noticed involved perhaps the most serious loss of any. This was on the Susquehanna farm of Mr. C. H. Pearson, a

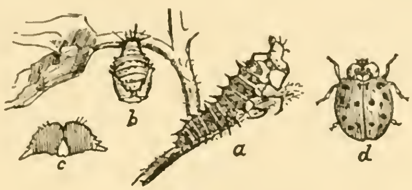


well-known Maryland packer, situated upon the Chesapeake bay in St. Mary's county, Maryland. Here, out of some 600 acres planted, about 500 acres were almost or entirely a total loss, which in dollars and cents means about $30,000. Two hundred acres were at once plowed under to prevent the spread of insects upon plants already dying. This and another field of 100 acres appeared as if swept by fire, so severe was the injury. The plants were fairly incrusted with lice, their whitish cast skins and the sticky honey-dew which they excrete.

The lice first attack the terminals of the plant, usually being found in the buds and between the unfolding leaves. Later they cover all parts of the plant, but feed mostly upon the under sides of the leaves. Thus they are always difficult of access by any spray. The mouth parts of a plant louse form a long, pointed beak, about one-third the length of the body. Inside this beak are several long, slender, sharply pointed bristles. By

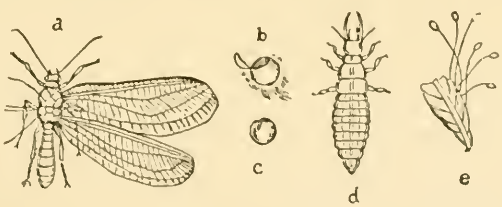
placing the tip of the beak upon the surface of a leaf and then driving the bristles into its tissue, the juices of the leaf or stem are secured and pumped up into the mouth, and in this way the plant louse sucks the vitality of the plant. The injury is, of course, entirely dependent upon the numbers of the pest, which, however, owing to the peculiar life history of these insects, is usually enormous. Moreover, by attacking the terminal growing portions of the plant, the pea louse is especially destructive, and the injury is very quickly appreciated.

The pea louse is about one-eighth of an inch long and of a bright green color, identical with that of the pea foliage. Both winged and wingless



forms will commonly be found, the winged forms becoming more numerous as the food supply becomes short. The fore wings expand somewhat over one-fourth of an inch, the beak is bent under the body when not in use, the antennae or feelers are long and slender, reaching to the rear of the body, and the "tail"—so called—is usually long and pointed. These, in brief, are the most striking characteristics.

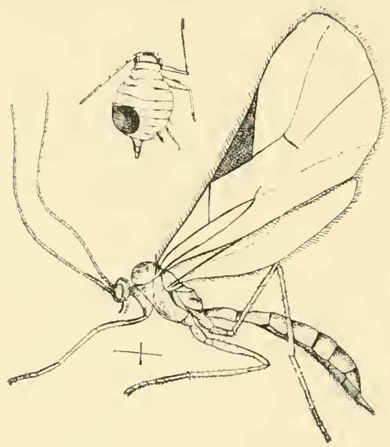
As before noted, the life history of plant lice is a peculiar one, and it is to this that their enormous number and consequent destructive power are due. As yet the complete history of the pea louse during the whole year has not been observed, neither the egg stage nor the winter habits of the



pest being known. Inasmuch as any general methods of cultural control must be largely based upon the complete life history of the pest, the importance of ascertaining it is at once apparent. Where the insect passes the winter is unknown. Generally plant lice lay eggs in late fall, which hatch in early spring, and doubtless this is the case with the pea louse, though they have not as yet been discovered. However, as soon as the peas are well started the lice are upon them and commence to multiply. This goes on at a marvelous rate, owing to their remarkable power of reproduction, which takes place without the egg stage, the usual first stage of most insects, but by the female giving direct birth to her progeny.

Throughout the summer all the lice are of this peculiar class of females, and only in the fall does a form appear which lays the winter egg. To all further growth each louse sheds its skin some three or four times before coming full-grown, when it may be either winged or wingless, but in either case soon commences to give birth to young. In the fall I have found that about twelve days is required for a louse to become full-grown, and that it then gives birth to from twenty to twenty-five young. During late spring the time for growth may be only ten days. At any rate, if you will take time to calculate the number of progeny from a single individual of a species which increases at a geometrical ratio of twenty every twelve days, you will soon see the reason for the enormous numbers and consequent serious damage done by these apparently insignificant insects.

But from this very fact of such an extraordinary power of increase we may expect to find a host of enemies to check the undue multiplication of such a prolific insect, for we know that such a condition is very largely a



result of the species having so many forms preying upon it that it must reproduce extravagantly in order to maintain itself in the struggle for existence. Only when for some reason the conditions for the development of the enemies of plant lice—such as predaceous and parasitic insects, diseases, etc.—are unfavorable, do the plant lice find a chance to increase in such numbers as to be excessively injurious. But, now again with a superabundance of food, the enemies rapidly increase, the plant lice commence to disappear and the balance in nature is again restored. In general weather conditions, subtle and but little understood, are responsible both for the destruction of the enemies of the plant lice, and often of the lice themselves.

Several insects feed upon the pea louse. Among the most valuable of these are the larvae of the pretty, yellow-banded Syrphus flies, which may be seen in large numbers hovering around an infested field, with their peculiar rapid flight, darting here and there, while depositing their eggs.

The young which hatch from these are small maggots, the most common feeding upon the pea louse being of a pure pea-green color, while others are brownish and variously colored, and are about one-third of an inch long. As illustrative of the numbers in which these occur and the good they may do, Mr. Pearson wrote that during the last few days he packed, his separators sifted out over twenty-five bushels of these "green worms." The small ladybird beetles, which as children we were wont to scare away to their children in burning houses, and their larvae, also fed almost entirely on plant lice, and all of the common species have been found consuming the pea louse. Several insects of minor importance also feed predaceously upon the pea louse. Usually, plant lice are very largely destroyed by parasitic insects, which as larvae live within the plant lice and thus kill them. When these become abundant every louse on a plant will sometimes be found parasitized. Strangely enough no internal parasites were bred by Prof. Johnson from pea lice secured in Mayland, and possibly it may be due to this cause that we are to attribute the enormous and unusual number of the lice. Late in the fall I found one species (Aphidius Washingtonensis, Ashm.) quite commonly infesting the pea lice, here on the experiment station grounds (Newark, Del.), and we shall be on the lookout for its appearance next year with some interest.

In addition to the insect enemies of plant lice, they are always peculiarly subject to the attacks of several fungous diseases, which spread among them very rapidly, and very often destroy large numbers of them in a very few days. These fungous diseases are especially prevalent during moist, wet weather, but disappear during hot, dry weather of mid-summer.

Thus Mother Nature has several most potent agencies for reducing the numbers of these destructive insects, but unfortunately, when for some reason these are diminished, and the lice accordingly become excessively abundant, the crop attacked is usually largely destroyed before the enemies of the lice again become sufficiently abundant to check their increase. These enemies of the lice cannot be artificially encouraged, but by recognizing them their destruction may often be averted.

What, then, can we do with this pea louse, and on the other hand, what is he going to do with us? The remedies and the outlook—what of them? As already stated, spraying or dusting the vines is impracticable, both on account of the closeness with which the crop is planted and the acreage involved, and because of the impossibility of reaching the lice, hidden as they are among the leaves. Fifteen per cent. kerosene is a sure remedy and

will not injure the plant, but from a careful trial I feel certain that a sufficient per cent. of the lice could not be killed to warrant its use. And so with all other insecticides.

Did we know the complete life history of the pest we might be able to devise some method of destroying it during the winter months, but this is a field for future study.

Fortunately early peas were but little injured last season, while late peas were a total failure. For one or two previous years, also, it was the late peas on which the lice were noticed. Thus, judging from our past experience, we can only rely upon the planting of early varieties for the securing of a crop. In general, in Maryland and Delaware, we would advise planting no varieties maturing later than June 1, and the earlier the variety the better.

As to whether the pea louse will be as destructive during the coming

season as during the past, is largely a matter of conjecture. After dying out during the late summer the lice appeared again in southern Maryland upon the fall crop in large numbers, and were present on a few vines here as late as the first of December, after several hard frosts had already occurred. Such unusual outbreaks of an insect pest generally occur only at rare intervals, but often the pest occurs in more than normal numbers for a year or two after the outbreak. Thus it is impossible to make any even probable predictions for the coming season. It is to be regretted that we have been unable to secure a more accurate knowledge of the life of the pest, and it is to be hoped that during the coming season we may secure such information concerning its habits as will enable us to devise some

means of successfully keeping it in control. The outlook is not encouraging, yet on the other hand it is by no means forbidding.

PROF. JOHNSON ON THE PEA LOUSE.

The next paper on the program was by Prof. W. G. Johnson, the Maryland state entomologist, whose address also covered "The Destructive Green Pea Louse."

I have to report here one of the most remarkable instances of the sudden appearance of an undescribed species of insect over a wide area which has ever come to my notice, and which is, perhaps, one of the most unique in economic entomology. For centuries hidden in obscurity, a little green louse appears suddenly over wide areas, destructively attacking the field pea, a plant heretofore practically exempt from the ravages of insect foes. My attention was called to it May 18, 1899, by Mr. C. H. Pearson of Baltimore city, one of Maryland's largest oyster, fruit and vegetable packers, in the following communication:

"One of my pea fields is entirely covered with a small green louse, which is sapping the life out of it, and if anything can be done to prevent it, I want to do it at once."

I made a personal inspection of Mr. Pearson's place, containing about a thousand acres, locally known as the "Susquehanna farm," situated along the Chesapeake bay, in St. Mary county, at the mouth of the Patuxent river, May 24, 25 and 26. Upon my return to my office, the 27th, and after a careful consideration of the conditions and facts, I summed up the situation in a letter to my friend Dr. L. O. Howard, United States entomologist, which I quote in part herewith as follows:

"I have just returned from southern Maryland, where I have been making an examination of the outbreak of aphids attacking peas in that section. I write this statement knowing that you are interested in anything of this kind, and at the same time to give you an opportunity to see with your own eyes what I have attempted to describe below. The place can be reached within a day's ride down the Potomac, and I am satisfied that you would be well paid for the visit to see the conditions existing. At the same time we would not care to have a public announcement made at the present time of this attack, as it might militate against the owner in a way that would be unpleasant for him, as his loss is estimated now at between $20,000 and $25,000.

"Without a question of doubt, the destruction caused by this insect is the most complete I have ever experienced. It is certainly a sad sight to look over a 100-acre field of peas and see them literally incrusted and covered with this insect. There is no hope to save even a fractional part of a crop in this field. It is one of desolation. As far as one can see the plants are shriveled, withered, and in many instances the leaves are blackish looking, as if a fire had gone over the surface of the ground, scorching them. The whitish cast skins of the insects, stuck to the drooping leaves in the honey-dew, which had been excreted by the insects everywhere over the

entire field, gives one the impression that a terrible plague has surely visited that section. The attack is not confined to this particular 100 acres, but is present in adjoining fields. The owner of this estate has planted this season 1,800 bushels of peas, besides using with them 130 tons of commercial fertilizers, covering an area of 600 acres of land in all.

"To say that the condition is discouraging to the owner is not necessary, in view of the fact that at present we are helpless, so far as a practical remedy is concerned. It is safe to say that if the present weather conditions prevail very much longer a total destruction of at least 200 acres will be the result. In fact, it appears to me, after a careful examination of the place, that the greater portion of the 600 acres is doomed to destruction within a few days, unless nature comes to our relief in the meantime. At the time of my visit yesterday the insects were flying over the field, already dead, in such swarms that it was rather uncomfortable to walk or ride through them.

"The attack, however, does not seem to be confined to that one particular region, as a correspondent from a Virginia county (Westmoreland County, Mount Hague), writes the Baltimore *Sun* that he has lost an entire field, sending specimens, since referred to me, which I find to be the same species. A careful and close examination of the peas in this neighborhood shows that they have been infested, though not to the same extent.

"This condition is certainly unfortunate for the people, mostly colored, of that section, as many of them are dependent upon the pea crop for employment, there being on the Susquehanna farm a large cannery, fully equipped with new machinery, boxes and a million tin cans ready to have utilized this crop of peas."

Briefly stated, this was my first introduction to the new pea pest. Further investigation showed that it was widely distributed over the State, and that serious injury would surely result to the large acreage of peas planted. The growing of peas in Maryland is a very important industry, and reliable conservative authorities have placed the loss the past season at $3,000,000, the principal cause being the destructive green pea louse. In many cases the destruction was complete, varying from mere garden patches to hundreds of acres. The final outcome of the crop where I made my first observations was fully as disastrous as we predicted. Four-fifths of the entire crop was a total loss; in other words, 480 acres out of 600 were literally sucked to death. In another instance only 110 out of 500 acres, belonging to the Louis McMurray Packing Company, of Frederick County, were considered worth cutting. It is useless for me to enumerate in detail all the places I have upon my notes where the peas were not cut at all. Suffice it to say that pea growers everywhere along the Atlantic coast consider that they have been visited by a veritable scourge. The attack has not been confined to Maryland alone, but I have records of its occurrence in Delaware, New Jersey, New York (Long Island), Pennsylvania, Virginia, North

Carolina and recently from Connecticut, Vermont, Maine, Ohio, Canada and Nova Scotia.

Talking with some of our largest growers, I find the pest was present last season in considerable numbers in certain fields, and some laborers (colored) even refused to pick peas from the infested areas. I am informed that it was present upon late peas on the New Jersey experiment station grounds the fall of 1898.

The species responsible for this condition of affairs properly belongs to the old genus Siphonophora, but as this name is preoccupied in the Myriapoda, and is also used to denote an order of oceanic Hydozoa I think it eminently proper for us to recognize Mr. Oestland's name, Nectarophora, for this genus. Specimens of the insects were submitted, through Dr. Howard, to the well-known authority on the Aphidae, Mr. Theodore Pergande, who considers it an undescribed species. Inasmuch as Mr. Pergande does not care to describe it, it is my privilege to name the insect, and I have called it Nectarophora Destructor, giving my description in the February number of the *Canadian Entomologist*.

The insects attack the young vines, clustering usually at first under and within the terminals. When the leaves become overstocked the lice cluster upon the stems, quickly sapping the life out of them. It was not an uncommon sight to see a vine literally covered with lice; indeed, whole fields of a hundred acres, as noted above. Besides the field and garden pea, we have found the same species on sweet peas vetch, and have kept it for some time upon clover. In my opinion some common plant is its natural food, but as yet I have been unable to detect it.

There is little opportunity for work upon this insect from the experimental standpoint, as it is practically impossible to spray a field of peas when they are growing for commercial purposes. They are drilled in like wheat and completely cover the ground. We have shown, however, that kerosene and water can be used to good advantage upon small patches. We used kerosene from 15 to 30 per cent. solution in the Deming sprayer without injuring the vines. It is not desirable to use a stronger solution than 15 per cent., but the vines will not be injured by a stronger solution. The latter part of June we used whale-oil soap very successfully upon late peas, at the rate of 1 pound of Good's potash-lye soap in 4 to 5 gallons of water. Some of our large growers used tobacco dust and air-slaked lime, swung broadcast, when the dew was on, over the vines. It was very satisfactory, but hardly warranted the expense and trouble. It is exceedingly difficult to reach these insects with either a spray or dust. With our present knowledge of the creature, we must depend largely upon natural resources for checking the multiplication of certain species. I paid particular attention to those insects and diseases that destroy plant life. Even at the time of my first investigation on Mr. Pearson's place (May 24-26) there were enough syrphus-fly larvae present for me to predict the destruction of most

of the lice by them, if weather conditions did not intervene to bring about that desired condition, before the end of the season.

I have observed three important groups of insects feeding upon the pea louse; first, and most important, the syrphus flies (see Nos. 2 and 3); second, the lady beetles, and third, the lace-winged flies. While all of these were found in every field examined, it was interesting to note the predomination of certain species in different localities. For instance, the syrphus-fly larvae were most numerous in the southern part and eastern shore of the State, while the lady beetles abounded in central, northern and western Maryland.

The real importance of the syrphus-fly larvae in the reduction of the species was shown beautifully in southern Maryland where they were so abundant the first and second weeks in June as to almost completely destroy the lice. Their presence, however, did not save the crop of peas this season, but what their almost innumerable number means for the future is hard to predict, and furnishes a subject for future thought and investigation. I am now going to quote a paragraph bearing on this topic from a letter from Mr. Pearson, dated June 12th, which reads like a fairy tale, but is nevertheless an undisputable fact, coming as it does from a man of undoubted veracity. He says:

"The insects (lice) started to disappear last week, and are now about all gone, but too late to be of any advantage to me this season. The last few days I packed the separators sieved out about 25 bushels of green worms, which no doubt proves that they destroyed the lice."

The "green worms" referred to were the young of the syrphus flies (see No. 2). In this connection I might state that I have bred three species of syrphus flies from larvae found feeding upon the pea louse. The oblique syrphus was by far the most common and important species. The greater bulk of the 25 bushels mentioned by Mr. Pearson consisted of this species. It was common all over Maryland, and was bred by me also from larvae feeding on lice sent to me from Virginia and Connecticut. The larva is pea green in general color, slightly streaked with white, varying in length from a quarter of an inch to a third of an inch when full grown. It pupates upon the leaves or stems of the peas, or upon some other object near by, rarely going to the ground. We have them upon corn leaves, near infested pea fields. The American syrphus was usually found associated with the preceding species, but not so abundant. The larva is larger than that of the oblique syrphus, brownish in color, somewhat mottled and larger. It also pupates upon the plant or even below the surface of the ground. The adult is also much larger than oblique, and can be distinguished from that species, even when on wing, by its bee-like hum. The remaining species, the cylindrical syrphus, was not common, but was found in two localities associated with the others, and is much smaller than either. Of the lady beetles four species were observed feeding upon the lice in the fields. Both adults and larvae were everywhere present in the infested fields. At the

time of my visit, June 30th, to the infested areas of Frederick County, I found pupae of their insects attached to leaves of peas, weeds, grass and corn—in fact most anything where the larvae could secure a hold. Sometimes three or four were found upon a single leaf. The lice were on the decrease, and it was clearly seen that the lady beetles and other predaceous insects present would soon devour those remaining. The larvae and eggs of the lace-winged fly were found throughout the infested districts of the State, and it has been an important factor in the reduction of the lice. The soldier beetle (see No. 3) was also observed by me feeding upon the lice in my garden near the college. This completes the list of predaceous insects observed and bred.

I was surprised, however, in not rearing any hymenopterous parasites from these lice. None appeared in any of our breeding cages, and not one was observed in the field. Dr. James Fletcher, the Dominion Entomologist of Canada, and Prof. E. Dwight Sanderson, of Delaware, inform me they have bred some parasites from this pest.

On the 18th of June I noticed a number of dead lice adhering to pea leaves in my garden, and inferred that death was due to fungous disease. The disease continued to increase until about the 25th of June, and finally disappeared. Sometimes ten or twelve dead lice, in all stages of development, were found upon a single pea leaf. Specimens were preserved, and will be reported later by my colleague, Dr. C. O. Townsend, our State pathologist.

As noted above, I saw the first specimen of this insect in May, and I have had it constantly under observation ever since. We have some very interesting facts. In the first place we have found no male, but plenty of females, attending strictly to business, producing living young. It is not an uncommon thing to find a female walking around over a leaf with a young one projecting from her body. They obtain their food by inserting their lance-like beak into the tissues of the plant.

We have a colony of lice now upon peas in our laboratory, where they are breeding at this time. That the lice can stand a considerable amount of cold, even freeze, and still revive and produce young was abundantly proven by us this winter. The colony in our laboratory froze up Dec. 23d. There was ice half an inch thick in a jar. We thought surely we had lost our "treasures," but to our surprise a few days later, as the weather moderated and the room warmed up, we found them as active as ever. I had specimens sent to me from New Jersey at my request, from Mr. A. Blakeley, taken from the field late in December. Mr. F. C. Chittenden, of the U. S. Department of Agriculture, tells me he saw a colony breeding on the agricultural department grounds in Washington on vetch, Jan. 27th. With all these facts before us, it seems very probable that the pest passes the winter as a perfect insect, breeding all winter when weather conditions are favorable.

As to the future, I confess it is hard to predict what the spring will bring

bring forth. There may be a repetition of last year's devastation, but I do not look for it. I cannot help believing nature will do her part in relieving the grower and packer of this terrible scourge.

Let us ask ourselves a few questions! In the first place, what has become of the untold millions of syrphus flies, lady beetles, lace-winged flies, soldier beetles, hymenopterous parasites, etc.?

I cannot believe they have been destroyed, and I reasonably look forward to spring when they will come out of their hiding places, hungry and ready to pounce upon the first louse that makes its appearance. If this holds true, then the louse will have a hard time to establish itself again, in such destructive numbers over the wide area named above.

As a final statement, I would say, in my opinion, it will be wise to plant peas this season earlier than usual. Even if the louse does appear in destructive numbers, the very early crop will have a much better chance for maturity. In Maryland I have advised some growers to plant in February.

I have been asked many times if I would plant if I was a grower? I certainly would! I would take my chance largely on the early crop, as one year's experience has shown us that the later peas, save a few instances, were almost totally destroyed.

We must speculate a little, for we have no past history of this species to deduct conclusions or make generalized statements from its previous habits and behavior. We have but one year's experience, a sad one for many a grower, behind us. Nature has done her work well, and there is nothing left for the economic entomologist to do other than to acknowledge his inability to cope with such mysterious forces, and keep plodding along in the darkness, hoping to get a ray of light here and there as he unravels some hidden truth.

Does it not seem that old Mother Nature is resenting the progress of civilization? She is calling a halt; but man, in his eagerness to gain a livelihood, is forging ahead blindly, apparently not heeding these warnings that he is going too fast.

CHAPTER IX.

Prof. W. G. Johnson of the Maryland Agricultural College, was one of the principal speakers at the Annual Convention held at Rochester in February, 1901. His lecture, being on the Green Pea Fly, was especially interesting to the canners of peas who were still battling with this dreaded insect.

The Professor spoke as follows:

I am to speak to you of the ravages of the Green Pea Fly, sometimes known as the Green Pea Louse. I will give you the reason for changing the names: This has been known from the beginning as Green Pea Louse and there has been fault found with that name and it has been thought best and wisest in the present circumstances to change the name in such a way that this insect which has become so notoriously established in the pea growing sections will not be connected with the pea; in other words, not connect this insect with the vegetable, and we have thought best to change the name Pea Fly to Green Fly, eliminating the name Pea entirely; and I think the name Green Fly should be referred to in our journals and then the popular mind and those consuming the vegetables, green peas, etc., will have no unpleasant connection with this insect. The term louse is rather repulsive when you stop to think of it, and that is objectionable on the face of it. Many persons reading of this insect would have reason to believe that in some way, if it is so abundant in the field as reports sent out would indicate, they might get a good percentage of them in the cans and in the canned goods themselves, and in that way no doubt the popular mind would be prejudiced. In the same way the word Pea Fly is objectionable. The popular public would just as soon eat a louse as a fly and you have got to eliminate the name Pea. If we refer to it only as Green Fly every one will know what we mean and the general public will not be alarmed in looking for Green Pea Fly or Louse.

I do not think this morning it is necessary to go into the history of this pest. I take it for granted most who are here this morning will be here this evening and at the Clam Bake we will introduce a part of the talk I had planned to give you, not in a stated lecture but throwing out in another way and using the stereopticon, and perhaps answering questions. This morning I would prefer to have questions asked direct and I will answer

them to my ability and that may perhaps bring out what will not be brought out to-night. There have been many questions propounded to me and I have declined to answer the individual, knowing they would be of interest to others, something about the general distribution of the pest. That is interesting to the canners and those interested in the canning business—where this pest has not yet been seen or not detrimental to the crops. Several gentlemen have stated to me that they have not seen the insect in certain parts of New York; at the same time I have had data stating to me that that green fly or the green creature we are talking about, is already established in Central New York. It was only seen in the late season and it was in the latter part of November when we heard of it in Cayuga Lake section and Seneca and Central New York. At the same time the inquiry comes to me whether it has reached up to Maine. We know it has. We have records of it late this fall on late peas in Maine and through other sections where we least expected to find it—all through the New England States—I can't name an exception where that pest has not attacked the late peas, or complaints coming from those who have attempted to grow the sweet pea for ornamental purposes.

You all know the reports that have come to us from the northwest, in the Wisconsin section, and we have records of its occurrence in Nova Scotia and in Canada. Late this fall a friend of mine in Canada writes me that late peas for ornamental purposes were quite affected this season.

It is very hard for us to deduce any general conclusions so we might make some statement concerning the future. It would not be wise from a scientific or business standpoint to predict the future or even venture a tradition which you might use as being conclusive for the coming season. I say it is practically impossible—for the history of this insect, you know, is only a recent one; it has only made two years' history. May 18th, two years ago, was the first occurrence, the first general record of note we had of this insect. Since May 18th two years ago that insect has been under observation up to the present time. I have the insect breeding in my laboratory now on peas and cow peas. I have the progeny of various generations which we have cared for through successive stages of this same green fly by way of getting at its life history. Those points are very well worked out but there are many facts that need working out as yet, especially with reference to the natural agencies which produce it, and study this insect with a possibility of elimination, for a time at least in the future, with the prevailing conditions which might have preceded it. We know as matter of fact that this insect was exceedingly abundant late last fall—enough of them, so we would say, left for seed. Some of you are familiar with the rapidity with which this insect propagates and with only a few left it is only a matter of a short time before you have a large progeny. In this group of insects we have the peculiar feature of the insect mother bringing forth living young. This is not an exceptionally peculiar case because we have some other insects which bring forth living young instead of eggs, but in

this case we have the insect mother bringing forth living young which soon mature and multiply with great rapidity. The young taken from the body of the mother on March 4th was carefully watched in a cylinder and eleven days later had reached maturity and was reproducing, lived forty-five days and during that period was the mother of 145 individual flies. You can recognize that that insect was a grandmother many times over before the last was born in that period of forty-five days. You take a little insect not larger than a pin's head and place it upon a plant a man would look at the insect alone and say it was not possible, of such a character and size to be of great menace to him as a farmer or as a canner, that would be his general conclusion if he saw the insect; but what it lacks in size it makes up in number. It is not the attack of a single individual but of the enormous aggregate you get in a few weeks. The history of this pest is being carefully worked out and we know practically all the details from early spring through the summer and through the winter. I am watching it carefully now, not only in the laboratory but in the field. It is still in the field in clover patches near Washington and in the south and still breeding and we will find it there this month breeding on one of the plants which this insect feeds upon. We saw it last January breed in the open field in the agricultural grounds; we saw it as late as December this year breeding in the open field. I saw it also in December in a southwestern state breeding in clover in the open field. There is still doubt as to the place of wintering of this insect in the extreme northwest. This is a statement many would doubt, but it is true that we have seen this insect frozen solid, thawed out and begin reproduction shortly after. We saw this a year ago; I was quarantined on account of sickness in my family, the pipes were frozen and unbeknown to the janitor all my plants and delicate little creatures were frozen in my laboratory. When I was released and went to the office I found not only the plants were frozen in the ground but the little creatures were frozen as stiff as icicles, and it occurred to me that although these little fellows were frozen they might thaw out and I could still save my seed. With a pair of forceps I took these little green flies, carefully, by the legs—because they will break off as easily as the finest spun glass—and although they were frozen, eight days from the time of that transfer they were producing, and that whole colony still goes on. It is not an uncommon thing for us to freeze insects solid and take them out and still have life though frozen. That is true of the notorious chinch bug; and that is known because this enters into the canning business, to those that grow sweet corn. Up in this section the chinch bug is another creature; we do not find it in the corn but in another place. The chinch bug has been known in several cases to be frozen solid in cakes of ice and then thaw out; it is not an exception to have these frozen solid and then recuperate and begin reproduction a short time after.

Some one advanced a theory yesterday that perhaps the cold weather of the northwest would freeze these insects out, but not long ago I had a talk

with the ex-governor of Wisconsin and he told me there was a time last winter when the thermometer was 46 degrees below zero, and we would therefore say that the cold winter would have no immediate effect upon them. The closer and colder the winter the better the effect upon insects as a rule. It is a fact the insects that live over winter in a dull state will find a secluded spot and live until open spring but if it is an open or rather warm winter and you have places where the sunshine is quite warm, in an exposed place, these insects will awake or come to life and go where the sun shines and then the cold will come and strike them and freeze them before they can get back, so that an open winter is as a rule more detrimental to the insect as a whole than a close, cold winter. The average farmer or person would think the reverse and would think the colder the winter the least prospect of an invasion of insects the following year.

So much for these facts. There are many other points I might bring out this morning but, as I stated in the outset, I believe at this hour it would be better for you to ask the questions.

(Some one said he would like to ask about the chinch-bugs.)

I would like first to confine this to the subject of the green fly and then take up some other subject.

Question: I would like to ask the professor if it is not possible for these insects to live through winter in the form of eggs?

Yes, there are many species that do live as eggs. Many familiar with fruit trees have seen a little green fly—or in this instance we can say green louse—around apples and the ladies will be familiar with the little green louse around rose trees. In the instance of the one on the apple you will find around the twig or about the bud a lot of little black eggs and sometimes covering the entire bud. In that condition those eggs remain there until spring; no degree of cold up to this time has been known to affect them. On the other hand, there has never been an egg seen of this pea fly or green fly; at the same time it is a question whether the opposite sex even exists. This is a case which we know is reproduction without a male. It is a very singular thing in nature, but at the same time up until very late fall the male of this creature has never been seen, and to prove that reproduction is possible without the opposite sex with the creature I mentioned a moment ago in generation after generation—the little creature from the time it was born taken and put on that isolated pea and the first born from that creature taking place at the expiration of eleven days, and one taken from that and in case of reproduction taking place at the proper time. I will say I have found recently in the colony in my laboratory, on cow peas, I have found one male, another professor has found two, but it is still a question whether that is the opposite sex of this same individual, but it is one of those peculiar things in nature that we must know all the facts about and study from that standpoint. The practical solution of this whole thing may hinge on establishing the fact that an opposite sex does exist. We know as a matter of fact that in many cases of

plant lice, of which this is one species, the early part of the season we have this organic reproduction, no male from spring until late fall, and the female at the last of the season producing an egg, each individual producing a single egg, that egg remaining throughout the winter and hatching in the spring and producing what is known as the stem-mother, but no male appearing again until late fall. This is a very peculiar freak in nature and the same thing may be the fact with this insect. Up to the present time we infer it is strictly an organic form with the possible exception which I have named: We have found the male on the cow pea and that may have been produced by some abnormal condition. I do not think the cow pea will ever enter as a factor; however, I have had them breeding on it in my laboratory, while generation after generation have disappeared on the ordinary pea. I have some facts which I will give you to-night, from the time the pea appears through the ground. Take a single pea plant and put upon it a young insect from the body of the mother, immediately after birth, and then calculate the time from the time of birth until that plant is destroyed by its own production. We have also discovered that that plant will succumb no matter how much water you can give it. Some one has asked the question, if we have plenty of rain, would not these plants overcome it? No doubt they would; of course, the stronger the plant the more it would resist, the same as with a human being; a strong, vigorous being might be in this room with a malignant disease and not suffer contamination. The same thing holds true in the plant world; and we have given them all the water and still at the expiration of a period that plant would simply begin to collapse, droop, grow yellow and die, which many of you have seen in the open field. I say these are facts we have to determine experimentally; but the mere fact of plenty of water and the attack of this insect will not save the plant; it has not solved the question; there are other conditions we have to consider. With damp, warm rain, which makes it possible that the green fly be carried away the question of fungous disease arises.

Question: Does it appear in the same place the succeeding year and the same form?

I would say yes and no. The local features determine that largely. In one instance an insect appeared on a farm, and it occurred the succeeding year in great numbers, but at the same time not as abundantly as the year previous. In another case on the southeastern shore, Maryland, two years ago it was exceedingly disastrous in a given field, while this year it was comparatively unknown. On the other hand, where it was abundant two years ago it was still more so this, in other cases where it occurred two years ago there were none, this year it was abundant. So there is no rule you can give in a given locality by judging of what occurred the year previous. We are still in the dark. Nobody knows or dare venture to predict what we are going to have next year. As an illustration, in 1899, it completely riddled a whole field while in 1900 it wasn't seen. I can name case after case in a

dozen States of similar character. I know one case where we would almost have ventured a repetition in a field where there were French canners, a field of peas belonging to Mr. Roe, a member, of Maryland, and at the time we saw them we would have predicted there would not be a can harvested from them, judging by the life in each bud, but a little later a great rain came and those dead insects were plastered and stuck all over those green peas. This year the best peas were taken from that section.

Question: Would a violent rain storm and almost a cyclone account for their disappearance?

Well, that would to my mind explain their disappearance largely, but at the same time there are other cases where the reverse is the rule, so no rule can be laid down until we have history back of us. After we have studied the thing ten years perhaps we can. I did venture to predict, early this spring they would see it in the northwest. I felt certain they would from the mere fact that they had them in Canada, and I felt almost certain that they would appear in the Lake Michigan region and that prediction held true, but I say that was not from any facts in hand that would warrant it, but the conditions were such that we felt warranted in making that prediction. You all know the outcome from the northwest this season. I do not think I will be violating confidence when I tell you that I have been told since I came to this convention that one individual lost eleven hundred acres in the northwest this season; I know another instance where five hundred acres was a total loss, and from that down to the little garden patch or the sweet peas in the garden of some of my acquaintances, and in most cases the cause of the death was not known to the individual until the whole question came up of the green fly on peas.

Question: I was going to ask you if you thought where there was an abundance of clover near, whether it would be a benefit or serve as a pasture for the fly?

It would be a benefit to the fly but not to the growers. I know some growers have been accustomed to growing clover with the peas and I would discourage it for this reason: we know the insect does live on clover and it likes clover and there is no doubt in my mind that is the original plant. In one of our counties in the southern states sixty-four acres of clover were destroyed by this fly so it was not even used for hay. There is no doubt in my mind that we must consider clover in the question.

The first record we had this season was from Mr. Roe, the 28th of April, and practically the same hour a letter was received from another gentlemen that this insect had ruined forty acres of clover in a county in the southern part of the State so they had been in that clover for many weeks, but that was the first Mr. Roe had seen it on his peas. The owner was attracted by the yellow condition of the clover and saw these green insects but he did not know what they were and sent a package to me. You see those insects must have been working there from the opening of spring up to the first of May, practically, and after they had cleaned out the clover if there

had been fields of peas just a few inches in height the whole colony would have attacked them. We have in the female form both the winged and wingless forms to care for the species; the wingless which must either be carried by the ant or plant and the winged. Where it is necessary to carry one insect by another, the ant usually carries. We will have something to say about that to-night. This will bring up the subject of lice on corn which this year has been on sweet corn. The root louse of the sweet corn, I will take up later.

I would say, be cautious about planting clover, especially in pea fields. There are two reasons, I do not believe it is good practice; clover is a legume, gathering nitrogen and storing on the nodules, and pea is a legume. You have two crops of the same general character and you must avoid that: it will not do to have clover and then peas, year after year, but you have got to bear in mind that that soil has got to have a certain amount of proper fertilizer. I do not believe, on the whole, that planting clover in pea fields, letting one succeed the other constantly, is good practice. It is necessary in some cases to follow that course. It would be best to hold off a year and then put your crop down and perhaps work it the first year in corn, if you saw fit, and then peas or some other crop which would be best suited for your rotation. I would be a little fearful, on large areas, in having one legume succeed another. I have known of some instances where peas have been on one territory for five seasons. That may hold, if that land is properly taken care of—like taking care of a man or feeding a horse—if you give the land the proper food, at the right time, that soil will increase or you can hold it at a given level. I can cite to you one instance back in an England experimental station, where they have grown wheat on the same land for forty or more years and they have not diminished the yield per acre. It is simply the vegetable plant food that soil needs.

Mr. Roe telegraphed us, as I said before, on the 28th of April, and a few days later Mr. Scott and myself were at Mr. Roe's place. I was satisfied that there was a clover field in the immediate neighborhood, where we would find these insects, and like a pack of hounds after the fox we looked, and we passed almost opposite corner, diagonally across, without finding the green fly, and then on almost a quarter of acre of clover we found something wrong with the clover. The plants were withering, looked as if they had been sprinkled with something; there we found the fly and we found the same disease in that clover we have been speaking about, prevailing. The bunches of clover were rather moist, a good deal of moisture at that time, and we found this same disease prevailing. We traced it back to a given locality, and in most instances that could be done. In other cases I know of pea fields set out in spots where there wasn't a clover field for miles around, that were badly affected. Where they came from—I will use an expression I heard this morning—the Lord only knows; where they came from I don't. There wasn't a clover near, and there were woods on either side: and I think we will find, when ferreted out, there are many plants on which it will feed.

Question: The question I was going to ask was not so much the rotating of clover, but I think our State (Wisconsin) is considered quite a clover State and much more so than other States where the fly has done so much damage and I wondered if where the clover were grown the pea would be so much damaged. We have a great deal of clover and grow considerable of peas and so far we haven't been bothered by it.

Mr. Johnston: Sometimes, like taking a dose of strychnine, a little bit is all right and a little too much is too much. You can use so much with a certain degree of safety; and in the same way I would apply this principle to clover: If your section is a great clover area and your clover is greater in extent than the pea industry I would say they might concentrate their attack on a given area. You know as a matter of fact they do distribute themselves very rapidly. On the 28th of April when at Mr. Roe's place you could just occasionally find an old female around on that forty-eight acre field, you had to hunt a great deal; a week later they were more abundant; a week later they were still more abundant, and about a week later there was scarcly anything left.

Question: The Clinton Canning Company of Rome informed me not long ago that some one connected with Hamilton College was studying the pea louse and found the egg; and it may be in the north they lay eggs and in the south they do not.

Prof. Johnson: That may be true.

Question, continuing: I wrote to our professor about it and asked him if he would not ascertain the facts.

Mr. Johnston: There is a possibility that it may be found. A man might find an egg now, which we very often do, and dare not make the assertion that it was that of the green fly because it might prove to be a different species, that is, a species closely allied to it. It is conceded that this insect is closely allied to one that has been known for a hundred years, or more than a hundred years, in England, known there as green dog—attacking clover; but the specific differences are so minute that they must of course be handled under a microscope. There is no doubt there have been similar insects working in England for a hundred years or longer: Just why this insect should appear here just now and not before is an interesting question. You have all been growing peas for years, but two years ago was the first that this insect was considered from a commercial point of view, but it is a commercial factor now.

Two years ago I was called into Washington County of our State to investigate the question of the army worm invading a millet field. I first scooped up many worms two or three inches long and examined them to see if there had been deposited an egg of a house fly, which is parasitic, on their back; if I could find that egg the worm would not mature. I found that 80 per cent. of the army worms in that section were parasitized of that insect. There are only 13 per cent. to reach maturity and the chances are that only 2 per cent. would reach maturity. With 2 per cent. it would take perhaps five years, from that 2 per cent. that is left, before they would be in

destructive numbers. All we did was to make some mechanical appliance to handle them, and we simply left them there—you could scoop them up by bushel basketful and we simply permitted them to remain there and the natural parasite matured and destroyed their percentage and as a matter of fact that insect has not been seen in that locality since.

In 1895, when I was located in the Champlain district, the army worm was not so much affected by the parasitic insect, but the fungous disease attacked them very much—which I will speak of to-night—how, while they were feeding on millet stalk they would be taken sick and would die before night. There were so many of those dead worms hanging and dangling to the timothy that they could not use it. That disease always attacks the army worm at the rear end of the creature, and it was not an uncommon sight to see an army worm living and feeding while the hinder part was decayed with disease. There was a field where nature was doing her work. Here is another field where a man finds it in his field and says I will not attack that, I will lean on the Lord. Just as sure as you do that you may rest assured you are going to wait a long time before the Lord is going to get around to help you, you have got to do your part. When you come to this pea fly it is a serious question and you have got to fight it. You have got to fight it as mechanics. This fellow has not a weak point any place, at least I have not found a vulnerable point and you have got to get Mr. Scott and others to work it out from a mechanical standpoint. I believe this will be solved from such standpoint. Most of the trade I think knows it; this little creature you can hardly see during the two years has been the instrument of destroying seven million dollars' worth of peas.

I don't care whether you are growing green peas or making tin plate or whether you are manufacturing machinery or fertilizer, this question resolves itself down to one of economics. It is not the man who is studying the little green fly but the one who is studying the whole industry. There are eighty-eight industries affected by this little green creature. Every industry represented in this convention is more or less interested in this question; and that is what I am here for; I am here to answer those questions. If I don't know I will say so.

Question: You spoke about these insects traveling. If they get started in one direction do they continue in that direction or do they branch off?

I cannot answer that definitely, but there is no doubt in my mind, on account of the delicacy of the wings of this insect, they will go with the prevailing wind. If you are in a section where there is what is known as prevailing wind, I would say they would go largely in that direction. I did see them in one case where they appeared in such great swarms it was uncomfortable to drive through them. That is where a field of about 260 acres was just at the point where there was no longer any juice left in the old plants for the green pea fly to suck and so each one that had wings took wing and the whole atmosphere was filled with them so it was uncomfortable to drive through them. That holds true with other insects. In the chinch-bug section when there is nothing left for them to feed upon, they are

going to get out and go where they can find the best feed and get it. On the other hand, that is about the only time the chinch-bug uses his wing. Some, you know, haven't wings, but they get there all the same, and it is only a question of nature, if they want food they will take flight. And insects will take flight in the spring to find a breeding place, a field of rye, etc. The same with the pea fly—I have only seen them on wing when they want to feed. I do not blame them for sucking a nice, juicy pea instead of a dry clover stalk; I would do the same thing myself. A nice, juicy variety will perhaps suffer more than some other.

Mr. Goldmark: You mentioned a little while ago this insect had been known in England for a hundred years. Was it ever known to exist in France, where there is a large pea district?

We can only go by history or record. That certain records of it both in France and England have been deposited from time to time. We infer that it was the same creature or similar in character. It has occurred in literature along that line. There is no history back of it. We are working in the dark. There is no important record. Another point we have: In some of our local press notices twelve or fourteen years ago records of invasion of crimson clover fields along the Potomac river by some insects of similar character; that is, the plants were killed or injured very seriously. We infer it was the same creature. While we haven't the specimens and no way of getting at it, there is no doubt in my mind it was the same identical chap we are discussing to-day.

Question: Did I understand you to say there was no solution found to destroy this insect in the way of spraying?

Yes, there are solutions found that will destroy it when you can strike it. You know it goes in the terminal buds, the breeding females will go inside and start their colony there and it is almost impossible to get at the insects within that fold; you can spray or you can dip that bud right down into the solution and it will form a bubble around it and that will burst when taken out and the little fellows will be all right in that bud. Some spray. We did this season. Mr. Pearson, the Baltimore packer, perhaps did more than any other one in America. He got ready for it, and we all know his heroic fight this year, and it seems to me Mr. Pearson gave it a thorough, practical test and from the standpoint of spray, up to this time we have had nothing that would do the work. From 5 to 20 per cent. would always be left irrespective of the area and manner in which you applied the spray. That is a pretty large factor, because it is only a few days before they will breed and you will have to go all over that again. It resolves itself down into a question of mechanics, as I said a moment ago, brush. You know very early varieties planted early have suffered less from these insects than those planted late. I understand there is to be a large number of acres of early varieties planted early. With the planting of so many early peas and planting them early, what is going to be the effect? Another year will tell us and will tell us whether we are going to plant broadcast or in rows. It is a question we have got to consider thoroughly. If I were

a planter and planting extensively I would be pretty cautious about getting late peas in drills; I wouldn't put all my crop in for early peas; I would risk the larger part of my crop in early peas broadcast, because at present there is no way of saving the plants when we have brushed and blown and sucked and you cannot get rid of them and cannot get at them. We have had men going through a field of fourteen acres blowing and brushing and thinking we would not leave any of the little fellows, and when we got the sucking machine on them we thought we had it solved. There is another question—that sucking machine worked all right in principle. If you can do it on a small scale may be you can do it on a large scale also, but when you get a 600-acre field—

Mr. Hubbard: How do you recomend planting, Professor?

I don't know, Mr. Hubbard; that is a question, I think, for you canners to decide. I am not giving you any recommendations. I am giving you my opinion. I do not want any man to go on and say, "I planted on the recommendation of a young man that was talking through his hat." I am simply holding it is a problem for every one to consider. I know as a matter of fact Mr. Pearson is not going to broadcast his. I know that if this is going to strike in Indiana we would not want to be in their boots if it strikes them late. Those light, sandy soils, you all know, dry out very rapidly. If they are broadcast you have no way of getting at them. With a drouth combined with the insect, the insect will not take a good strong plant, but they will take a sickly or weak plant every time. If there is anything that reduces the plant in vitality you can rest assured that insects are going to attack that particular plant. And with drouth and a plant weakened in vitality a man wants to be careful on these light, sandy soils, and use the cultivator frequently. It may not be necessary and some have said, "It don't pay; I get about as big result as the man who plants in rows;" on the other side the man that planted in rows what he got was profit to him. You can rest assured if he got anything at all in comparison with the man in the other locality—the man that got them by cultivation and brushing them, etc., he can just credit himself on his ledger with that much; and that will hold good in any locality. What is going to be good for the northwest I don't know. I am going to be cautious about my statements. I am not going to advise you when I have had no experience myself. You may broadcast two and one-half or three bushels to the acre if you choose. I would rather take my chances with two and one-half bushels in the drill, where I have a chance to work, than three broadcast and take my chances. It is an insurance, in other words, you can afford to put on that crop to insure yourself of the only possible way of saving the late crop, just as you would put insurance on your factory. If you did not burn this year is no reason why you should not insure next year. The man that broadcasts his late peas, if this insect does strike him as I said a moment ago, has not a peg to stand on. In the northwest, where these insects breed in a field of five acres in such great numbers that the gentleman him-

self said it didn't seem possible that nature could produce such numbers as there, it seemed as if they must have rained down—there wasn't a pea left in that field—they simply withered and died. He is going to plant his peas in drills. I bet he doesn't plant them broadcast, if he plants them at all. These were very late peas—about the 20th of July the insect struck them.

Question: If they had been drilled would it have saved them?

Would it be possible to save them if in drills, because that insect seemed to breed more rapidly? Here is a point: I do not believe it possible, more rapidly than in the south or central states, but there may be conditions that exist—that there are greater breeding individuals in a field —but I don't believe the period of birth is any more rapid than in any other place, and I think these insects were there, probably in the early fall, but he didn't see them and it wasn't until he saw the decline of the peas that he saw them. Mr. Roe was looking for them, and many of you laid paper down as Mr. Chisholm and Scott suggested to see if you could find the green fly. That is what Mr. Roe did, and I feel confidently certain that if the Wisconsin people had done the same thing they would have seen them four or six weeks in advance of the time they did, when there was a possibility of saving the crop. Plants become so infested that you can only see the flies, you could not see the plant at all. I have seen them when they stood, with their heads in, so closely on the stems and leaves that you could not see the plant. If you should go in and kill every louse the plants would never have overcome it. Apply the same condition to a man—cover a man with leeches so that you cannot see the skin—I do not care how well you feed him—keep him in Powers' dining room with a dozen waiters around him—he is not going to live. He cannot stand the drain on his system. It is the same with the plant on which this insect feeds. The insect has a lance-like beak which he inserts in the tissues of the plant itself, and you will almost always find what we call an oxidation of the enzymes, an oxidation of the coloring matter or materials within that tissue and that is effected by the insertion of the beak. You will find a whole plant yellowing from the oxidation or oxidizing effect that you get from the insertion of this lance-like beak.

Mr. Greenabaum spoke of spraying with peppermint.

Yes, some insects have pretty good smellers and there have been many experiments and many advantages taken of that fact, to repel insects. For instance, you take some of the butterflies and their sense organs are exceedingly delicate, and they detect an odor, and we have gone on the supposition if they are attracted by a sweet smelling substance they would be repelled by an unpleasant odor. Take, for instance, the rose bug which is attracted by the sweet smelling substance—for instance we know the magnolia is literally covered by these bugs, and we know they are attracted by these sweet smells and we take the reverse and think perhaps they will be repelled by foul substances. We take something we might call rotten eggs,

potassium sulphide, when in solution it smells like rotten eggs, and spray the plants thinking these insects would be repelled and at the same time it would not affect the plant but it did not have the effect we expected—it seemed to be impervious to it.

Mr. Goldmark: Is there any vapor that would be injurious to the life of the insect?

Mr. Johnson: Yes, there are a number of chemicals we have tried to use—bisulphate of carbon, a very volatile liquid a little heavier than air. Mr. Scott, Mr. Roe and Mr. Chisholm rigged up a canvas and with oilcloth making a place perhaps larger than this room air-tight, and then they introduced this bisulphate of carbon. But it would be pretty difficult to cover a large field. The result of the experiment was not very satisfactory. We know as a matter of fact that this is one of the most deadly insecticides.

On the other hand, the hydrocyanic gas, as has been suggested, is still worse. The gas is lighter than air and the most deadly gas used in science, so that we could not for a moment trust that in the hands of the canners. Some of the machinery men could use it all right—but the lungs filled with hydrocyanic gas would kill a canner. It is used largely in California. They are obliged to use it in orange orchards, and they use canvas covering the entire tree. We are applying some in some of the orchards in the east.

The San Jose scale, in a 1,000-acre orchard, it was discovered that about 6,000 trees were infested, and they were all fumigated last fall, so it is being used by nurserymen for the destruction of the scale before dissemination from the nursery, and it is also used by seed houses, especially in elevators where grain is stored in large quantities. I have successfully fumigated some of the largest mills. One mill in Canada used 75 pounds of potassium cyanide at one dose. In Baltimore I fumigated in one case 60,000 cigars which had been attacked by the cigarette beetle.

Question: How about the syrphus fly?

The syrphus fly is one of these natural factors that appear almost from the beginning and has kept the insect down to a certain extent. In no case does it seem to have increased in the same percentage with the green fly. While the green fly was producing at the rate of twenty to twenty-four the syrphus fly was reproducing only at the rate of three or four. I have found a number of unrecorded species feed on this green fly and the syrphus fly feeding in that section. We have got to look out for it and the canner must familiarize himself with it so he can interpret what he sees. That is what we are going to do. We are going to make bugologists out of the canners. Already some of the more progressive canners are asking us to help them fit up microscope outfits. You can go so far and call in and have the experience of others occasionally and have a lesson given you now and then. You have the equipment back of you to do it. It gets itself down to a matter of business. Some of you will within ten years, I have no doubt, have a microscope on your desk and use it just as much as pen and ink.

Question: Can you brush them off—

The little fellows just born would be destroyed if you get them in the dirt; but with the older individual it would take an inch and a half to two inches earth to destroy them. Some would work out of an inch if the earth were dry, but if moist it would be impossible for them to get out of half an inch.

Another question is the time.

We found that one of those old ladies would live in her grave of an inch and a half of earth over forty-six hours. You can't cultivate the second day—you must wait at least until the third day.

Question: How near can these rows be placed together and be cultivated sucessfully?

I would say thirty inches. Some advocate twenty-six, but I recommend thirty inches.

The question has been asked, how these peas are dropped in these rows, and I think that is an important point. At Mr. Pearson's we found the use of a single row drill, with fertilizer attached, and that dropped the peas thirty or thirty-five to the foot, and as they came out they would spread about three inches just as they run down and we covered them up. Between the fertilizer and the seed peas we had an agitator which covered the earth and we had shoes behind it which just covered the peas and fertilizer.

Question: All done in one operation?

Yes, sir; one covered them in the neighborhood of two inches.

Question: You think that is deep enough, do you?

Well, of course, you might say two inches. Some of them might be four; but I would say two inches.

Question: Some one asked about worms in the ears of sweet corn.

In the South it is known as the cotton-boll worm, and in the middle central south it is known as tomato worm, because it works in the tomato, and in the north it is known as corn ear worm because it works in the corn. I do not know of any remedy except in the south they plant corn around their cotton and the sweet corn is used as a trap. There is a suggestion, if the sweet corn growers could plant a crop a little earlier than the one you expect a little later, it might prove a preventive. They fly at night, you have seen them fly at night, a drab colored moth. It goes to the corn and deposits its egg in the silk and the worm works its way down into the ear and leaves a bad, objectionable ear. You might plant an early crop which you are planting as a trap for the worm. That is a difficult problem. You have got to be governed by your season. If the spring opens early you have got to get ready. Do not throw the whole bulk of your crop in at one time. This is particularly true of the late crop. There are only two broods of this insect and the first brood is not so great. They crawl down to the corn and pupate in the corn. It is the second brood that raises havoc with the corn.

CHAPTER X.

The following paper by Professor Sanderson was to have been read at Milwaukee at the Annual Convention, February, 1902. Owing to blockading snow-storms, the Professor was unable to reach the Convention city and the paper, therefore, was not read. It was published, however, in the Canner and Dried Fruit Packer, as a part of the Convention proceedings. The paper was as follows:

GREEN PEA LOUSE.

(*Nectarophora pisi Kalt.*)

The green pea louse continues to be the most important insect pest of interest to the canning trade. This pest has now been excessively destructive for three successive seasons, and though less abundant the past year, there seems to be every reason to believe that it is fully as liable to be injurious in 1902 as in previous years, and it is not at all improbable that we may have to fight it more or less every year. It is safe to say that during the past three years it has occasioned a loss to those growing peas for the cannery, market and seed, and to the canning trade, of $5,000,000 or $6,000,000. I have endeavored to secure some figures as to the total amount of the pea pack upon which to base a rough estimate of the loss sustained, but have been entirely unsuccessful except for Delaware. The above estimate is therefore only a good guess after carefully considering the available figures.

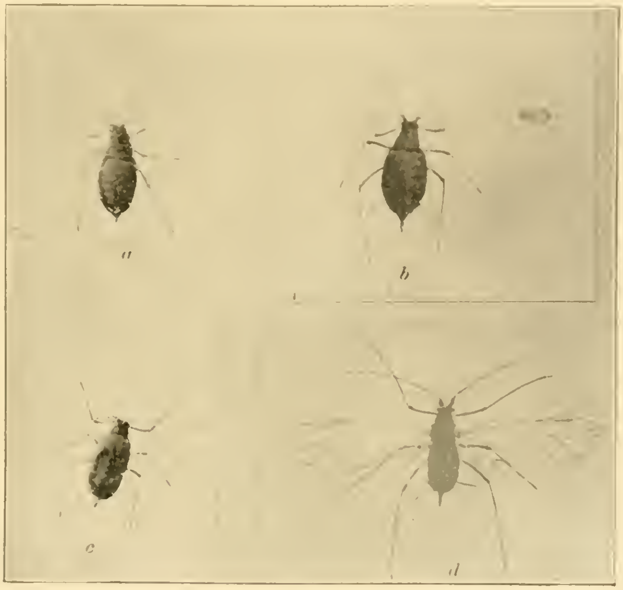
When the pea louse first appeared so destructively in 1890 we naturally were led to believe that it was a new pest. Further study has shown, however, that it has been well known in Europe for about a century. In England it is known as the green dolphin, and is one of the worst pests of peas, clovers and vetches. Messrs. Kirby and Spence, English entomologists, writing in 1815, give an account of the damage done peas, which is very similar to our own experience. "Those aphids which attack pulse (peas) spread so rapidly, and take such entire possession, that the crop is greatly injured, and sometimes destroyed by them. This was the case in 1810, when the produce was not much more than the seed sown; and many farmers turned swine into the pea fields, not thinking them worth harvesting. The damage in this instance was caused solely by the aphis, and was universal throughout

the Kingdom, so that a supply for the navy could not be obtained. The earlier peas are sown, the better chance they stand." It is also remarked that the pest is worst in dry seasons. The insect has been known in this country for about fifteen years, though never injurious until 1899, except in one or two localities to clover. In Europe the pea louse has a long list of food plants. We have found a variety of it upon lettuce. A recent report from South Africa states that it is very common there upon sweet peas and alfalfa, though we have not observed it to attack alfalfa in this country. Specimens from South Africa prove to be identical with the American and European species. Like many plant lice, however, this species is quite variable, so that three or four quite distinct varieties can easily be distinguished when closely compared.

I presume that the structure and habits of this pest are now well known to all of you, still it may not be amiss to briefly sketch the most important points for the benefit of those who may not have attended the last two meetings of the association.

The pea louse passes the winter on clover or vetches. About May 1st the winged females spread to peas, upon which they give birth young, which develop into wingless females. These females, as do those of subsequent broods, give birth to live young without intercourse with males, which occurs only in the fall, and without laying eggs, as do most insects. Reproduction goes on very rapidly until the latter part of June. Winged lice develop as often as the food plant becomes overcrowded. About twelve days are required for a louse to become full grown. Prof. Johnson has shown that in the spring a female gives birth to 110 to 120 young. In the fall fewer young are born; only about twenty-five by each female, in October. Thus it is due to this power of extremely rapid reproduction that the aphids so quickly become numerous and do such serious injury. By July 1st the lice are almost all exterminated in the latitude of Delaware, both by predaceous and parasitic insects and disease, and are but rarely seen during midsummer. In September they become common again, multiplying very rapidly on the few late garden peas then to be found. Late in October they migrate back to clover. The winged female which migrates from peas to clover is much smaller than the summer form, and the feelers and the back between the wings are blackish. About November 1st a few winged male lice appear on the clover. They are similar in size and color to the migratory females, though slightly darker, and having black spots along the sides of the abdomen. By analogy with the life history of similar plant lice, such as the apple leaf plant louse, the appearance of a male would lead one to expect that the young deposited on clover by the migratory females would develop into true females which would lay eggs. But so far as observed such is not the case with the pea louse. The young born upon clover develop into viviparous females, which go on reproducing until severe weather sets in, and possibly without interruption in an open winter. Possibly farther north true females and eggs may occur, though careful search has not as yet revealed them. Early in the spring the lice commence reproducing

upon clover, and if they multiply without any check from insect enemies or disease they spread to peas as soon as clover becomes overcrowded, or when approaching ripeness it loses its succulence, and they find peas a more desirable food. The pest is principally spread by the winged females being carried by the wind, they being often carried several miles, as shown by their being blown aboard vessels in Chesapeake Bay from the shore. The manner in which they spread from clover to peas has in most cases been quite interesting, in that they migrated to only the late varieties of peas. Next to a badly infested field of clover was a large field of peas, early, medium and late; only the medium and late varieties were attacked, the medium but



THE GREEN PEA LOUSE. (*Nectarophora pisi Kalt.*)
A. fourth stage wingless female; B. wingless viviparous female and young; C. pupa; D. winged viviparous female. (Author's illustration.)

slightly, and hardly an aphid was to be found on the early Alaska. Whence this nice sense of taste?

The winged lice are from one-eighth to one-seventh of an inch long, with the wings expanding about two-fifths of an inch. Most of the body is of a pea-green color, and light yellowish brown between the wings and on the head. The eyes are red. The legs, antennæ or feelers, and honey tubes are yellowish, tipped with black. The wingless females are similar in size and color, but are much broader across the abdomen, and the honey tubes are somewhat longer. In the young stage immediately preceding the winged

adult the wing pads can be seen on the sides of the body, whereas the wingless young are almost exactly like the adults, except that the tail is slightly shorter. Like all plant lice, the pea louse is a sucking insect. That is, its mouth parts consist of a long tube or beak, the tip of which is rested upon the surface of the leaf. Within this tube are four long, slender, needle-like bristles, which are worked rapidly up and down, lacerating the tissue of the leaf and thus setting up a flow of its juices, which are then sucked up through the tubelike beak. With large numbers of the lice sucking out its juices the plant soon withers and dies. Of course, with such a mouth structure it is of no use to apply poisons to the surface of the foliage for this pest, and if we are to kill it by spraying, some spray must be used which will act as an irritant or clog the breathing pores. This is accomplished by using kerosene and water or whale oil soap.

Before passing to a consideration of the remedies for this pest, let me call your attention to some of the most important agencies which hold it in check, namely, insect enemies, disease and weather conditions.

The pea louse seems to have but few internal parasitic insects preying upon it, though many plant lice are almost entirely held in check by these parasitic flies. In 1899 but few parasitized lice were found and those in the fall. In 1900 they were more numerous, probably about 5 per cent of the lice being killed by them in Delaware, but being of relatively little value in holding the pest in check. These parasitic flies are small insects, even smaller than the lice. They deposit an egg upon a plant house, the maggot hatching from which feeds upon the juices and tissues of the louse, ultimately killing it. The dead louse swells up, becomes brown and dry, having a very characteristic bladder-like appearance. When the maggot is full grown it transforms to a pupa, which soon turns to the adult fly. In emerging from the dead plant louse the fly cuts a smooth, round hole, the piece cut out often remaining attached, like a lid.

Syrphus Flies.—Among the most beneficial insects predaceous upon the louse are the maggots of the syrphus-flies. Three species very commonly feed upon it, the American syrphus-fly (*Syrphus Americana Weid*) being the most numerous. These syrphus flies deposit a single oval, white egg in a colony of plant lice. From this hatches a small maggot, which becomes about one-half to five-eighths of an inch long when full grown, of a green or brownish color, mottled with reddish, and with several pointed tubercles along the back and sides. These maggots have no legs nor distinct head, the head segment looking much like the rest of the body. But in it are a pair of small, stout hooks. When a louse is grasped by these it is held aloft, the maggot waving it to and fro in the air, and the juices of its body are quickly sucked out. In this manner I have observed one of these maggots to eat twenty-five lice in as many minutes. Late in the season when these maggots become numerous the refuse from the vines will be almost green with them, and they can be scooped up by the basketful. Two other species of syrphus-flies (*Spliacroplioria cylindrica Say.*) with similar habits were common. One of these (*allograpta obliqua*) was badly killed off by internal

parasites. One of these is a small wasp-like fly (*Bassus lac'otorius Fab.*) and the other similar to the parasitic fly feeding on the pea louse. So all parasitic insects are not beneficial; some, like these, preying upon insects themselves beneficial to man's interests.

Lady-bird Beetles.—Almost all of the common lady-bird beetles feed upon the pea louse, though they do not become abundant until early in June. These little orange, or reddish, black-spotted beetles, lay their small orange-yellow eggs in small clusters on the pea's foliage. From them hatch active little six-legged larvæ, which have been fancied to resemble miniature alli-

AMERICAN SYRPHUS FLY.

A. larva or maggot eating a pea louse; B. puparium, or pupa case, from which adult fly has emerged, end broken open; C. adult fly. (From photos by Author.)

gators. When full grown these larvæ are about one-half an inch long, blue or black, spotted with orange, and with numerous small warts or tubercles bearing black spiny hairs, scattered over the body. Each larva then attaches itself to the leaf by its tail, so to speak, and sheds its skin, transforming into pupa, a dozen of which are often found on a vine. The pupa hangs pendant from the leaf for a week or so, when the adult beetle emerges from it. Though both the larvæ and adults of these beetles eat large numbers of pea

lice, they do not become sufficiently numerous until too late to prevent the worst injury.

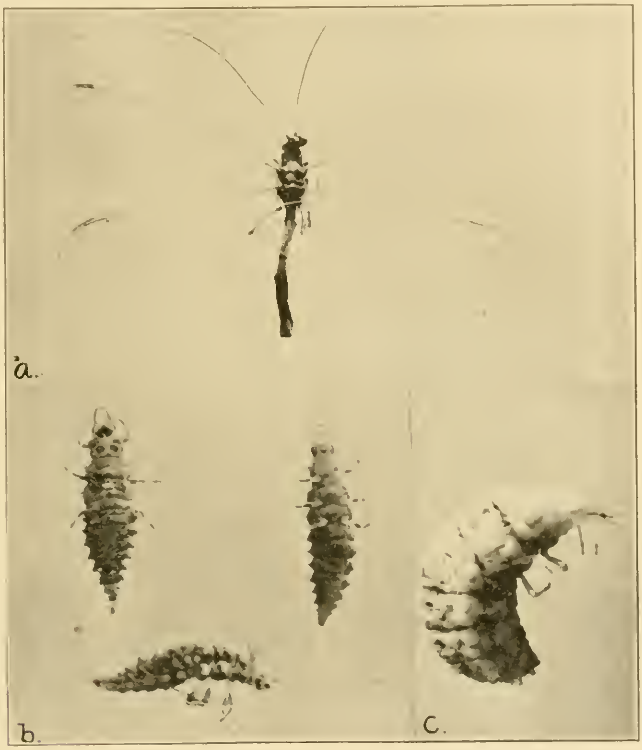
The Lace-Winged Fly.—This is one of the most interesting enemies of the pea louse. Its larvæ are quite common in the pea fields and consume many a louse. The adult fly is a bright pea-green color, with the veins of the wings forming a fine lace-like network, and with shining golden eyes, on account of which it is often called "Golden Eyes." Its eggs are laid singly, sometimes several on a leaf, and each is placed on the tip of a stalk of silk. Were it not for this ingenious device, when a young larva hatched it would undoubtedly devour all the remaining eggs. As it is, older larvæ often eat their younger brothers and sisters. These larvæ are smaller and much more active than those of the lady-bird beetles. Projecting from the front of the head are the two long sickle-shaped jaws, which are hollow. With the tips of these a louse is firmly grasped and its juices sucked into the mouth through the hollow mandibles. When full grown the larva spins around it a small globular, glistening, white silken cocoon, and within it transforms to the pupa, which in due time transforms to the adult fly. I found that one of these flies laid about forty-five eggs in a day in confinement, they hatching in about a week.

Many other insects feed upon the pea louse, but these have been the most important observed in Delaware. Though they do a great deal to lessen the numbers of the lice, they do not multiply with sufficient rapidity to enable them to materially check the lice until the worst injury has been done, so that in years when the louse is injurious no dependence can be placed upon them, though most years they undoubtedly are one of the most important factors in holding it in check.

Disease.—The most important enemy of the lice is a fungous disease—*entomophthora aphidis*. Lice killed by this disease are shriveled and covered with a sort of brown mold. In 1900 dead lice killed by this disease were found on clover early in the season, but not in any quantity until June 11. After that, so rapidly did the disease destroy them that a week later but very few lice were found, and almost all were diseased. Diseased lice were common on peas in the fall of 1899, but were much more numerous on peas and clover during the fall of 1900. In 1890, when clover was injured by the lice in Delaware in May, they were destroyed by this fungus by May 12. This disease also holds the louse in check in South Africa. As yet no means is known whereby this disease may be propagated. Could some method of growing it be found, it might be the means by which the pea louse could be effectually controlled.

Causes of the Outbreak.—Primarily, I believe the cause of the unusual outbreak of this pest in 1899 and its injury during the past two seasons to be due to weather conditions. To the peculiar weather conditions were doubtless due the disappearance of two of the factors which go to hold the louse in check. The severe blizzard of February, 1899, may very probably have killed off many of the internal parasites of the louse, and thus left the latter free to increase abnormally. This seems the more probable as but

few internal parasites were found in 1899, and their being more common in 1900. But the chief factor in nature's control of this pest seems to be the fungous disease. The growth of this disease requires wet weather, and is prevented by drought. April, May and June, 1899, in Delaware, Maryland and New Jersey, were together the driest for the past ten years and, with local exceptions, this was true throughout the Atlantic coast, Ohio valley and Lake region. Not only this, but there had been a marked deficiency in rainfall during the two previous years (1897-98) in the spring and for



LACE WINGED FLY. (*Chrysopa oculata Say.*)

A. adult fly; B. partly grown larvae; C. pupa. (From photos by author.)

the whole year, even the spring of 1896 being exceptionally dry in Delaware. In 1899 the fungus did not destroy any considerable number of the lice until about June 18, and their destruction seems to have been most largely due that year to the predaceous insects. In 1900 the disease appeared much earlier, destroyed large numbers of the lice and their disappearance by the 18th of June was most largely due to it. In 1890 the lice were destroyed

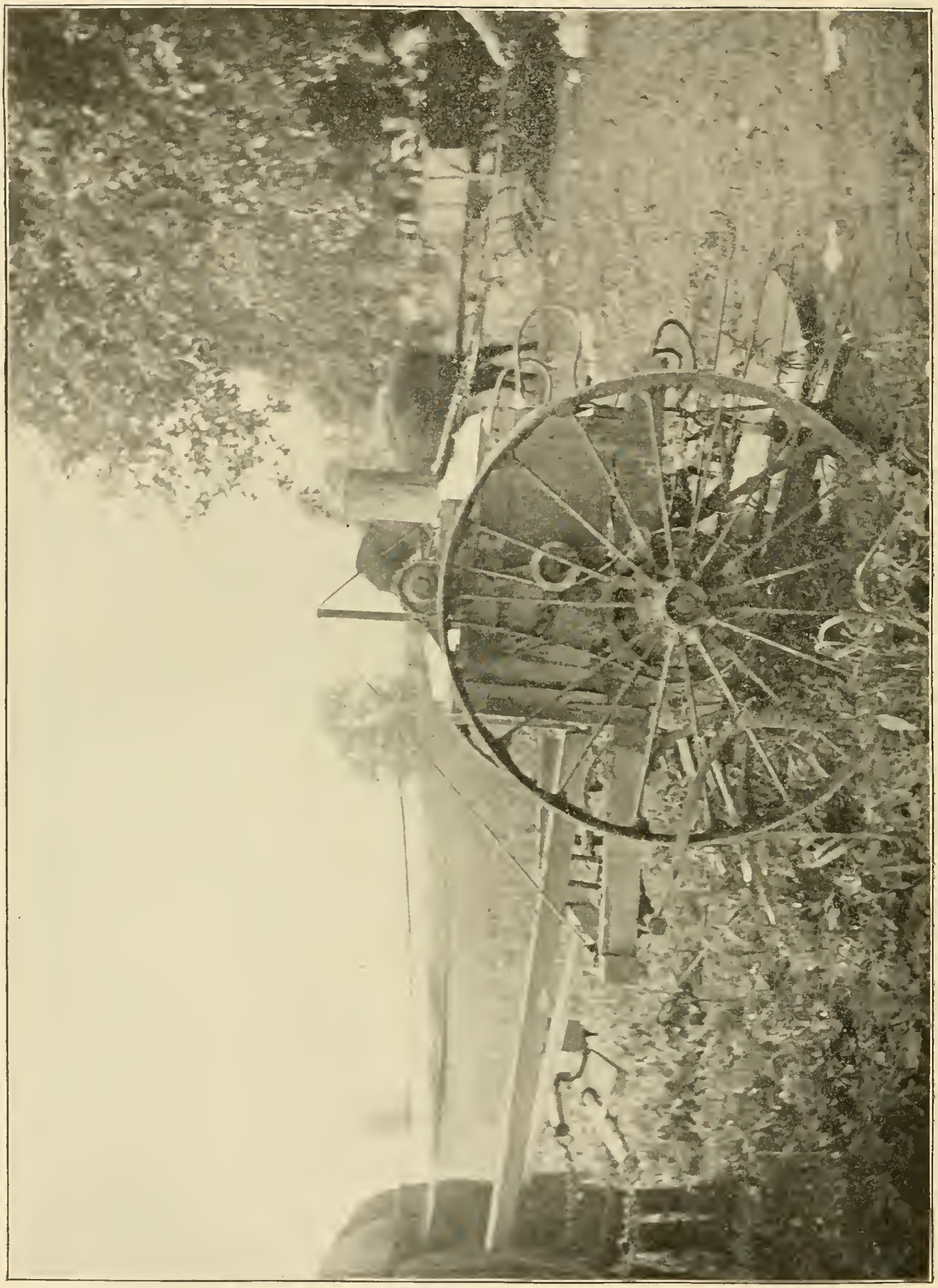
by this disease at Newark, Del., on clover by May 12. The rainfall of May, 1890, was above the normal, at Newark, and the preceding winter was a mild one, corroborating the view that a wet spring is favorable to the development of the fungus, which destroys the aphids on the clover and prevents their spreading to the peas. As before noted, Kirby and Spence many years ago stated that the louse was much worse in England in dry seasons. The past season we had an unusually wet April in Maryland, Delaware and New Jersey, a more than normal rainfall in May and about the average in June. Throughout the pea-growing states there was a normal or excessive rainfall during these months. As a result in Maryland, Delaware and New Jersey there was little or no damage to early peas by the louse, and by no means as much to late sorts as in the previous two years, and I am informed that in the north but little damage was done.

HOW TO COMBAT THE PEST.

Preventive Means.—Management of Clover.—Inasmuch as the lice spread from clover to the peas, it will be advisable to plant as little clover next the peas as possible. In the spring the lice should be carefully watched on the clover. Should they become overabundant, the management of the clover will depend on several factors. It has been planted as a cover crop to be turned under, it will probably be best to turn it under deeply at once, even though it has not made the desired growth. If planted for hay, its treatment will depend upon whether it or the peas are of most value.

Planting in Rows.—Peas sown broadcast or planted in 8-inch drills have universally been much more seriously injured by lice than those planted in rows twenty to thirty inches apart and cultivated. Furthermore, peas not sown in rows afford no opportunity for brushing, cultivating or spraying. It is therefore *absolutely necessary* that peas be planted in rows as long as there is any danger of the appearance of the louse.

Remedial Measures.—Brushing Followed by Cultivator.—Prof. Johnson found in 1900 that when peas were planted in rows the lice could be readily knocked from the vines by means of brushing with a pine branch, and that by thus knocking the lice off between the rows and cultivating at once the lice would be destroyed by their dying from suffocation under the earth or by the heat of the soil. Prof. Johnson stated: "Where the lice are brushed off on the ground in the hot sun, with the thermometer varying from 94 to 96 degrees Fahr., they are actually roasted to death in a few minutes. The temperature of the ground was from 115 to 119 degrees Fahr. The cultivation should not be repeated until the third day, as it requires usually something over forty-eight hours for the destruction of the adult insects covered by earth" (i. e., if the soil is not hot enough to kill them at once). "Peas that will not admit of frequent cultivation should be brushed at midday." By the use of this method several parties in Maryland were in 1900 able to save considerable areas of peas. This method was used with some success in Delaware, but it was frequently found that when the soil was

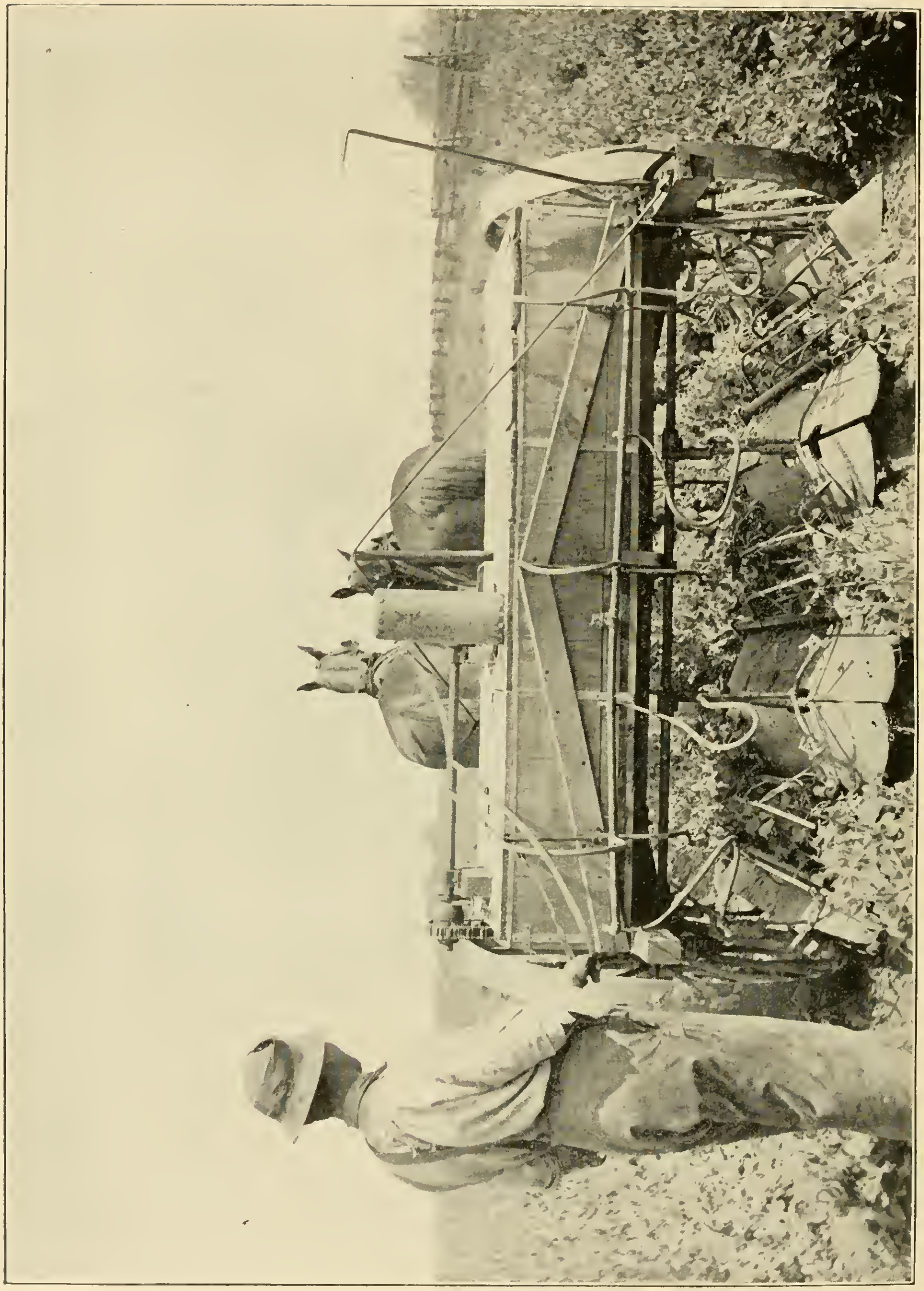


moist it would form small clods after cultivation and that the lice would then merely crawl out from under them back to the vines.

Brushing into Pans.—To meet this difficulty Prof. Johnson devised an arrangement into which the lice might be brushed and thus caught. This is modeled after the "hopper dozers" used in the west for catching grasshoppers, and consists of a long, shallow pan the width of the rows and five or six inches deep, with one or two cross partitions. In the bottom of this

EGGS OF LACE WINGED FLY AND PEA LICE KILLED BY FUNGOUS DISEASE.
(*Entomophora aphidis.*) (From photo by author.)

pan is placed a little water, which is covered with kerosene. This pan is drawn between two rows, while a boy on each side brushes the lice into it, where they are soon killed upon coming in contact with the kerosene. The pan should be frequently cleaned out, so that it will not become filled and thus prevent those falling in from coming in contact with the kerosene. These pans may be easily and cheaply made and operated at small cost. The



hopper dozers have been used for many years in Minnesota and the west, over thousands of acres, with the best of success, and we would commend this method of fighting the pea louse in preference to the "brush and cultivator" method, if spraying is for any reason unpracticable or undesirable.

Spraying.—In 1900 I experimented at Mr. Cannon's in a small way in spraying with a kerosene and water mixture. We found that 15 per cent. kerowater was ineffectual against the louse on a hot day, as it evaporated so rapidly that no injury was done the lice; 25 per cent., however, killed the lice—all it hit and did no injury to the vines as far as we tried it—on about one-fourth an acre. Almost all of the lice were thus killed by thoroughly spraying the vines by means of an attachment to a kerowater pump, by means of which four rows were covered at once, one spray nozzle to each row. But knowing that at this strength the kerosene was very liable to injure the vines, when used on a large scale, no further tests were then made. Our work convinced us that with four nozzles to a row, so that the vines could be thoroughly sprayed, and with the pump geared to the wheel of the cart, the pea louse could be successfully combated by spraying, even on a large scale. Prof. Johnson also tried spraying with whale oil soap, but without much success. We believe that this was due to an insufficient number of nozzles, as he used but one nozzle to the row, so that the spray came from above and the sides of the plant and under surfaces of the leaves were doubtless not covered.

We were led to give attention to the possibility of profitably spraying for this pest on account of the fact that some growers had not been successful with the "brush and cultivator" method, it failing to destroy a very large percentage of the lice brushed off on cool days or on stiff soil forming lumps when cultivated. Furthermore, it is evident that in brushing, using either the cultivator or the pan drawn between the rows, the large numbers of the adult lice might be destroyed, inasmuch as the young lice in the buds are not disturbed, it would be impossible to check the development of the first brood of the pest by brushing, as might be done by a spray which would reach and destroy the young lice resting securely between the terminal leaves. We therefore planned to construct an attachment to a barrel sprayer which would cover several rows with several nozzles to each row, and had submitted our plans to several pump companies, when we learned that Messrs. Brakely of Bordentown, N. J., had constructed a satisfactory sprayer, and had in 1900 successfully combated the pea louse with it, using some 140 barrels of whale oil soap. Upon corresponding with Messrs. Brakeley we learned that they considered the sprayer entirely satisfactory; after having sprayed a large acreage and saved their crop by means of spraying last year, that they had duplicated their order for 140 barrels of whale oil soap, and intended to spray their whole crop of 500 acres this year. Feeling satisfied that these gentlemen must have solved the problem of spraying the pea louse, we dropped the construction of a pump and awaited a public exhibition of their machine with interest. This took place on May 13, when Messrs. Brakeley kindly invited a number of persons interested to inspect the working of the

sprayer in the field. Among the party were Dr. J. B. Smith, New Jersey State Entomologist.

At a distance the sprayer looks something like a large grain drill. It consists of a large tank, containing a simple pump, with air chamber above tank, which is attached by gear to one of the wheels of the two-wheeled truck. Beneath the tank are pipes leading to nozzles, and the guides and lifters for holding the vines erect while they are being sprayed. The sprayer covers three rows at once, the peas having been planted in this way, but the inventors think that planting two rows at once and having a sprayer covering two rows would be preferable. As the sprayer passes along the vines are picked up by a wooden V-shaped piece, similar to a plowshare, and pass between parallel iron bars which hold them upright. These bars are movable, so that they do not tear the vines. Above each row is a cluster of three nozzles—Bordeaux nozzles are used—one directed forward, one backward and one straight down. On each side of each row are two nozzles, one directed forward and one backward, and just above the ground on each side is a nozzle directed upward, so as to give a thorough under spray. On either side beneath each row is a wide board which catches all the lice knocked off by the machine and upon which they are sprayed. The whole under part of the sprayer—nozzles, guides, etc.—can be thrown up about a foot by means of a lever, permitting the turning of the sprayer, and can also be adjusted for different height vines. The machine is simple and practical.

Messrs. Brakeley were just finishing a twenty-four-acre pea field, upon which six sprayers had been working half a day, when we arrived. The vines were about fifteen inches high, being Champion, Jr., a medium late, sweet wrinkled pea. The lice were not very numerous, though almost every tip contained a small family of fast-maturing young. The vines were very thoroughly covered by the spray, and as nearly as we could approximate it, from 80 to 90 per cent. of the lice were killed; had they been thick, at least 95 per cent. or more must have been destroyed. On May 20 Mr. Brakeley wrote me that he could find but very few lice in this field, which was then about ready to cut. Later he wrote that where the vines were sprayed promptly about May 13 to 15 a good crop was secured and but little injury was done, but that where spraying was delayed till later the crop was considerably damaged by the louse. Whale oil soap was sprayed at the rate of one pound to six gallons of water. It had been used more dilute, but it was found a larger quantity was then necessary, and it was therefore better to use it stronger to avoid handling of material. When the vines are small about 160 gallons, and when nearly full grown 300 gallons are used per acre, which at 3 cents per pound of soap would mean $1.50 an acre for materials. The soap was readily mixed with cold water, one barrel of soap being mixed to form three barrels, and this then dipped into tanks in which it was diluted and carried to the sprayers. The water for the tanks was pumped up from a small brook by means of a traction engine. One tank carried the soap solution for each sprayer. With six sprayers, six tanks, engine and three extra

men, fifty acres a day were sprayed at a cost of $42.50 for labor and $75 for materials, or a total cost of $244—say, $2.50 per acre.

This may seem a good price to pay for combating the pea louse, but when one spraying will insure a first-class crop of medium and late peas, while otherwise they would be of inferior grade, those who are growing a first-class article can well afford the expense, and were the lice thick enough to threaten the life of the crop, two sprayings would certainly be profitable. Mr. Brakeley sprayed his whole crop of 510 acres, all owned by himself, and though the lice did not seem to be thick enough to do any serious damage when examined May 13, yet it seemed to Mr. Brakeley and myself that spraying would be profitable, which, as before stated, proved to be true. The sprayer was invented by Messrs. Brakely, sons of A. Brakeley, of A. Brakely & Sons, and is covered by patents (668,951, Feb. 26, 1901, and 669,818, March 12, 1901). They were unable to give us an exact estimate of the cost, but it was thought by those present that they could be built to order for $150 to $200, and possibly less if manufactured in numbers. Of course a small grower could hardly afford to own and operate such an outfit, but where peas are grown for the cannery on contract, the canner might own and operate the machine, or some one owning a traction engine or doing similar work might find it profitable. Messrs. Brakeley's sprayer was granted patents upon the combination of the device for lifting the vines and nozzles for spraying them. Various arrangements of nozzles for spraying crops in rows have previously been patented and put upon the market by spray pump makers. Early in the season, while the vines are still upright, we believe that any machine which will spray two or three rows with four or five nozzles to the row, will be found satisfactory —and early in the season, before the lice have become numerous, is the time to spray with profit. But as the vines fall over and run a device for lifting them is absolutely essential, and Brakeley's sprayer is of value.

If the pea louse is to be with us every year—as it now looks—and we must fight it by spraying, it will be found desirable to raise low-growing sorts and to plant in perfectly regular rows.

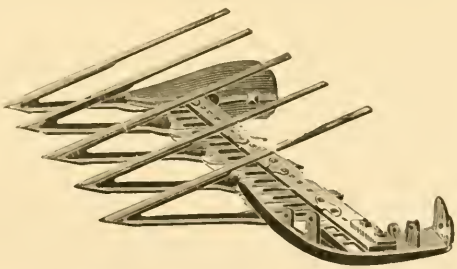
Should the weather conditions be unfavorable for its development, the next season may see a practical disappearance of the pea louse, but, on the other hand, it may be as bad as ever, and should it not occur in 1902, or in 1903, it may appear any spring as suddenly as in 1899. As it should be fought early in the season to prevent injury, I believe that spraying will be found profitable, and that the possession of a first-class spraying outfit, with a supply of soap, all ready for use, and then its prompt use, will solve the problem of growing peas in spite of the pea louse. I do not know that it is now in order, but I believe, gentlemen, that it is proper, and I can support the good deacon in saying, "Let us (s)pray."

CHAPTER XI.

OUTLINE OF PROCESS OF PACKING PEAS BY THE MOST APPROVED METHODS.

BY
CLARENCE H. PLUMMER

Formerly it was customary to plant peas, for canning factories, in rows in the field, and make several pickings over the same field as the crop matured, but at present the method of planting and packing most used is as follows: The peas are sown in drills, same as in the case of small grains, and when the most advanced parts are fully matured, but before the ripening or hardening process sets in, the vines are pulled and all pods removed, put into bags and carted to the factory to be podded by the "*Pod Hulling Machine*," or where "*Vining Machines*" are used, the entire vines, with adhering parts, are carted to the factory on racks similar to hay racks.



THE SEIDL PEA MOWING ATTACHMENT

The hulling operation is the first that is performed. This is accomplished by the use of machines which beat the peas out of the pods—the *Pod Hulling Machine* or the *Vining Machine*. These are very similar in construction, the former treating the pods after they are removed from the vine, and the latter treating the entire vine with pods attached. Both machines discharge the hulled peas separate from the pods or vines.

The peas are next treated in a machine known as a *Cleaner*, in which by

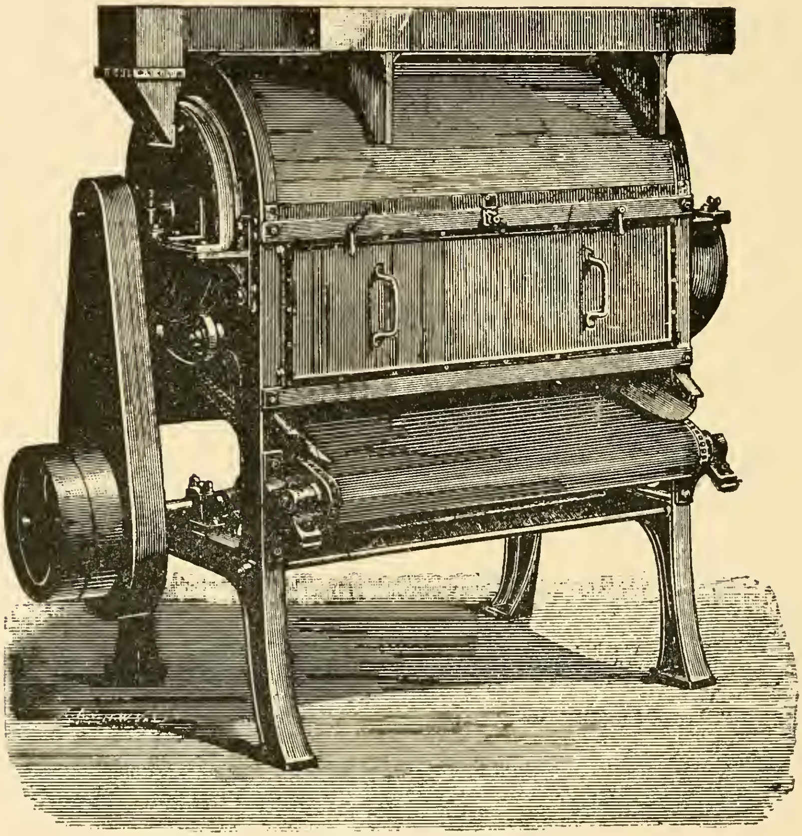
means of an air blast or through suction in combination with large and small screens, all fine dirt, pieces of pods, and other foreign substances are as far as possible removed. The peas then go to the *Grader,* which separates them according to size, each size being discharged into the separating receptacle, from five to seven sizes being the usual gradation. To these various grades are given the trade names of Marrowfat, Early June, Fancy Sifted, Extra Fancy Sifted, Petit Pois, etc.

The next operation is the *washing* and *hand picking* (the peas may be washed before or after picking, or even before the grading, if so desired). The washing is done by means of revolving cylinders of perforated metal or wire mesh provided with perforated pipe, which throws a spray of cold water upon the peas as they travel forward. For the hand picking, devices known as *Pickling Tables* are employed, the peas being automatically distributed upon a belt or apron which slowly passes under the hand of the operator, who removes all discolored peas or foreign matter. The peas are now ready to be blanched, the prime object of which is to thoroughly remove all the juices which may remain in the peas after the former operations, and also to moderately parboil the peas. The *Blanching machine* best adapted for this purpose is described as follows: A series of three tanks through which the peas are carried by means of spiral flanged conveyors, each mounted in and riveted to a perforated drum or cylinder. The whole comprising a series of revolving conveyors which pass the peas along through each successive tank of water. The spiral flange, which moves the peas along, is wide enough to project above the surface of the water so that the peas cannot lag behind. The water is introduced into the last tank first in a small stream, overflows from it into the intermediary tank or tanks, and then into the first tank, whence it overflows. In the first tank the gum and juices adhering to the peas are nearly all removed by the first bath; in the second succeeding tank the contamination of the water is reduced, and in the last tank the water is scarcely contaminated at all. This method of thoroughly washing the peas is superior to the old methods by which the peas were blanched in the same water all through the time they remained in the bath. In this machine the peas are constantly moving and rolling. All receive the same heat and the attrition of the peas one against the other cleans them very thoroughly.

After blanching, the peas, as they are discharged into buckets from the blancher, are usually again sprayed with cold water and then delivered to the *Filling Machine,* which measures and places in each can the desired amount of peas and hot liquor. The most approved machines of this type take the cans in single line and discharge them in single line without the use of trays or other separate receptacles for holding the cans while being filled. From the Filler the cans pass through the operations of wiping, fluxing of the caps after same are placed on the cans, and the sealing or soldering of the caps onto the cans. The wiping, fluxing and capping operations are preferably accomplished by means of combined *Wiping and Capping machines,* which take the cans in single line on same general principle

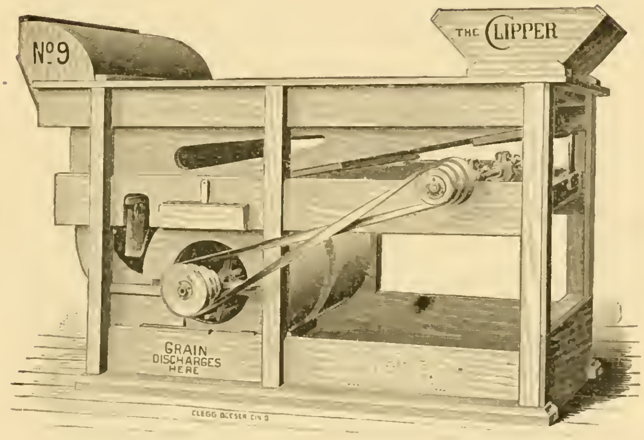
as the Filling Machine, and which work in automatiic connection with the latter. It is extremely desirable that each operation should be expeditiously performed that the peas may not deteriorate through delay in handling. The special machines now on the market designed to operate in continuous automatic line make this important consideration possible of accomplishment. The final treatment of the peas, now hermetically sealed, is the complete sterilization of can and contents, and is accomplished by means of *Pressure Retorts,* or the use of other *sterilizing apparatus* adapted to maintain a temperature greater than boiling point of water, such as the automatic calcium processing system. After sterilizing it is important that the cans be quickly cooled, as continued high temperature tends to cause cloudiness of the liquor in the can. The whole aim of the entire process must be to produce an article which, when opened, will present bright, clean liquor, whole and evenly graded peas, uniform in color, tender, attractive in appearance, and palatable. There is probably no vegetable packed in cans which will so unmistakably show the degree of care taken in its preparation than the finished can of peas.

Modern Canning Machinery mentioned in Mr. Plummer's article on the Process of Packing Peas.



THE PEA HULLER

Modern Canning Machinery, mentioned in Mr. Plummer's article on the Process of Packing Peas.



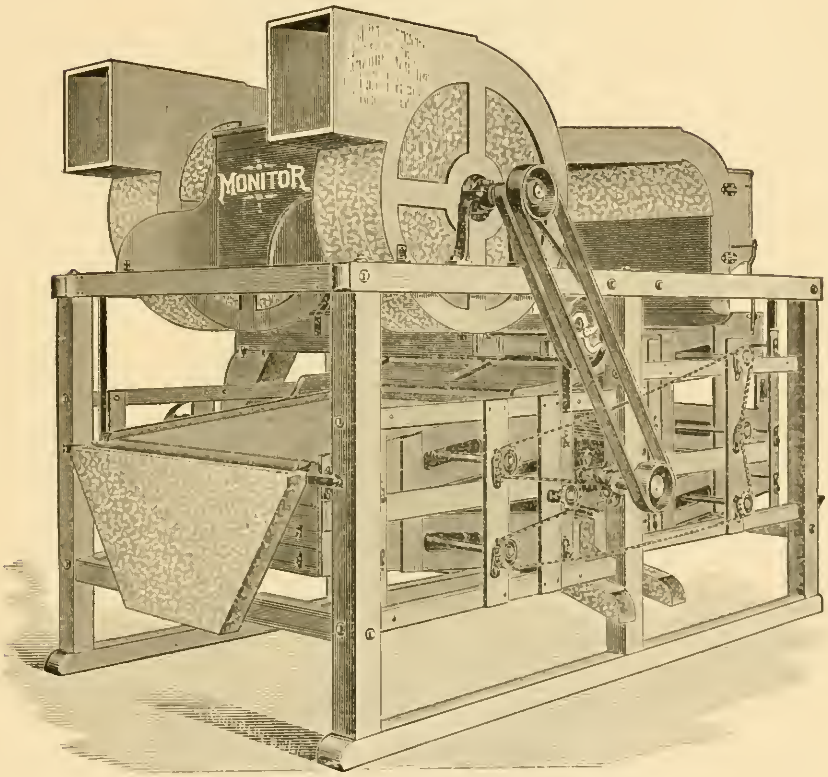
"CLIPPER" PEA CLEANER.

Modern Canning Machinery mentioned in Mr. Plummer's article on the Process of Packing Peas.

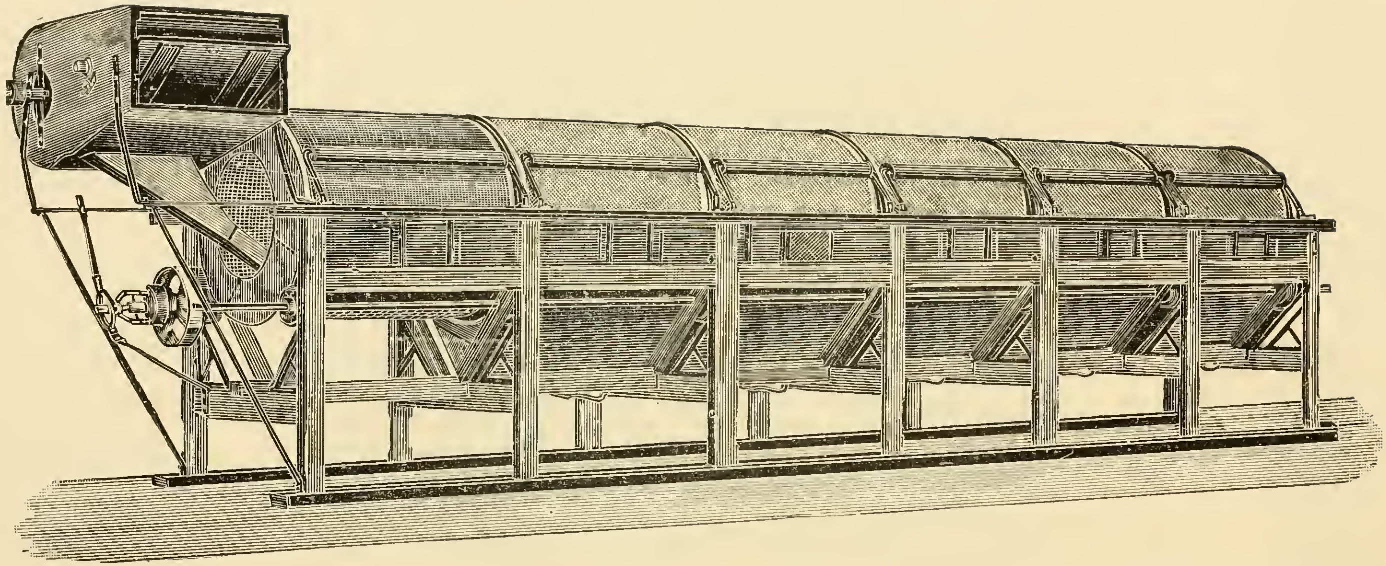
"CLIPPER" PICKING AND SORTING TABLE.

This illustration shows the foot machine, a series of these tables side by side can be operated by power from one shaft.

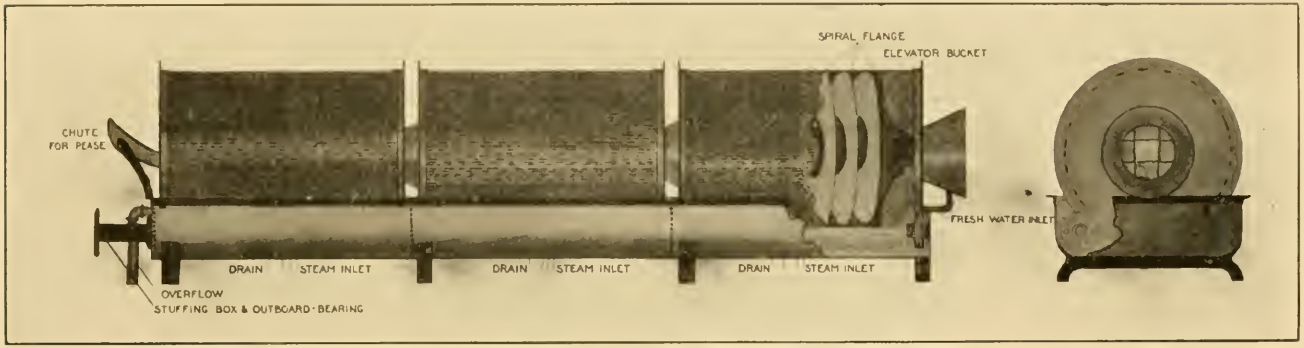
Modern Canning Machinery, mentioned in Mr. Plummer's article on the Process of Packing Peas.



THE MONITOR PEA SEPARATOR OR GRADER.

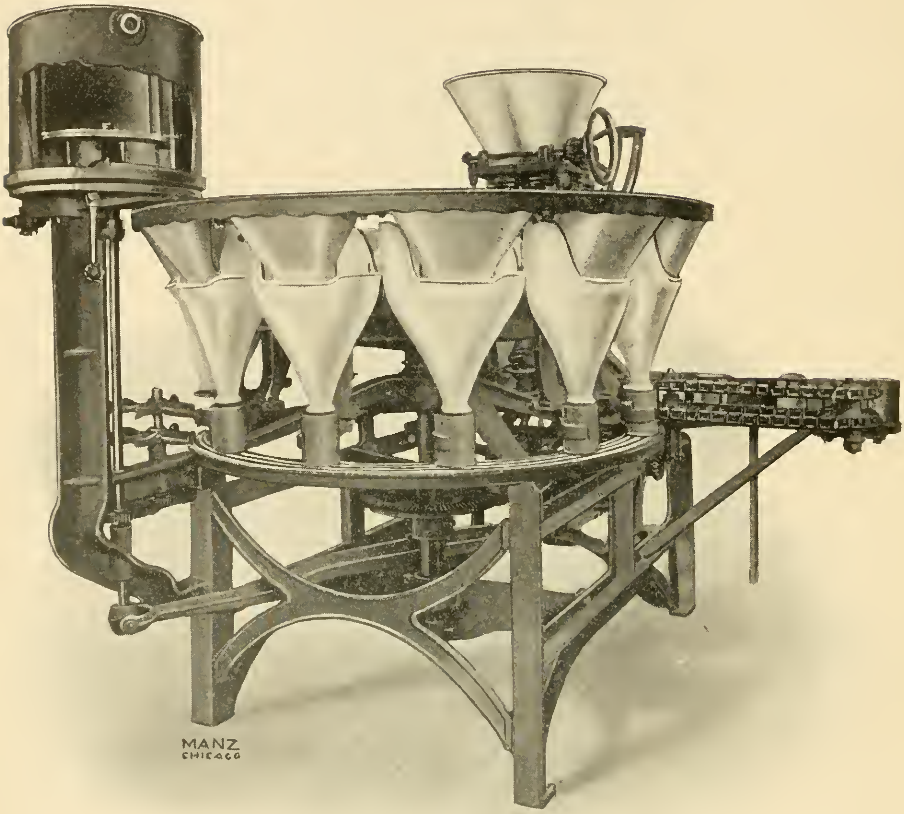


SCOTT'S ROTARY PEA SEPARATOR OR GRADER



THE PLUMMER PEA BLANCHER

Modern Canning Machinery, mentioned in Mr. Plummer's article on the Process of Packing Peas.



THE PLUMMER PEA FILLING MACHINE

(AUTOMATIC BRINER ATTACHED)

The machines and apparatus for wiping, fluxing, soldering caps, and sterilizing are the same as employed in packing corn, etc. See Prof. Prescott's article on Process of Packing Corn.

THE SPRAGUE CANNING MACHINERY COMPANY

MANUFACTURERS OF

AUTOMATIC CANNING MACHINERY

and Dealers in Canning Factory Apparatus and Supplies

FACTORY
HOOPESTON, ILL.

SALES OFFICE
42 RIVER STREET
CHICAGO, ILL.

DANIEL G. TRENCH & CO., CHICAGO
GENERAL AGENTS

BRANCH SALES OFFICES

PHILADELPHIA, PA.,	GEO. E. LOCKWOOD, AGENT
PORTLAND, ME.,	HENRY R. STICKNEY, AGENT
UTICA, N. Y.,	S. F. SHERMAN, AGENT
SAN FRANCISCO, CAL.,	BERGER, CARTER & CO., AGENTS

Catalogues and List of Publications relating to the CANNING INDUSTRY furnished on application.

ONE COPY RECEIVED
NOV 26 1902

LIBRARY OF CONGRESS
0 014 420 917 5